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A PRELIMINARY ANALYSIS OF THE ACANTHOCEPHALAN GENUS *CORYNOSOMA* IN MAMMALS OF NORTH AMERICA

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Corynosoma, as a valid generic concept, was first recognized by Max Luehe in 1904. Prior to that date the early species of ACANTHOCEPHALA, later recognized as belonging to this genus, were assigned to the all inclusive assemblage which went under the name *Echinorhynchus*. Both birds and mammals have been recorded as definitive hosts of the various species of *Corynosoma*. Several species have been listed from both of these host groups but there is a growing body of evidence which indicates that each species is restricted, biologically, to either birds or mammals as normal definitive hosts.

More than thirty years ago the writer became interested in the members of the genus *Corynosoma* that occur in mammals. At that time there had been but few collections taken from North American hosts and even some of the exploring expeditions into the arctic, where the genus is particularly well established, failed to secure any specimens of this genus. Because of the scarcity of the material available in the initial stages of this study and the fact that some of the material was in a relatively poor state of preservation, the impression was gained that all of the specimens might be recognized as representing two highly variable species. In the literature there had been no specific identification of any *Corynosoma* from North American mammals. Furthermore, not one of the European species had been described in the detail that since 1911 had become recognized, through the work of Luehe, as essential for specific recognition in many of the other genera of PALAEACANTHOCEPHALA.

Relying upon the fact that seals and other marine mammals find no physical barriers to their movements in the arctic seas, the belief that the species of *Corynosoma* from the American arctic should be identical with those from hosts in Eurasia was readily adopted. The further fact that many of the species of marine mammals are continuously distributed between the two hemispheres made this assumption appear all the more reasonable. The ACANTHOCEPHALA of northern Europe have been under continuous study for more than a century and a half. Although new species are even yet being added to the lists of acanthocephalan parasites of fishes and birds, there has come to be a widely accepted belief that only two species of the genus *Corynosoma* (*C. strumosum* and *C. semerme*) are commonly represented in the marine mammals of northern Europe. Incomplete as were the available descriptions of the species, generation after generation of European scientists recog-

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nized the faulty concepts as part of the heritage of common knowledge that passes without necessary validation from one generation of workers to the next and from one laboratory to another. A realization of the inadequacy of the definitions arose only when students of other countries began to attempt to apply the available means of differentiation to materials which, on insufficient grounds, were assumed to be identical with the forms encountered on the European continent.

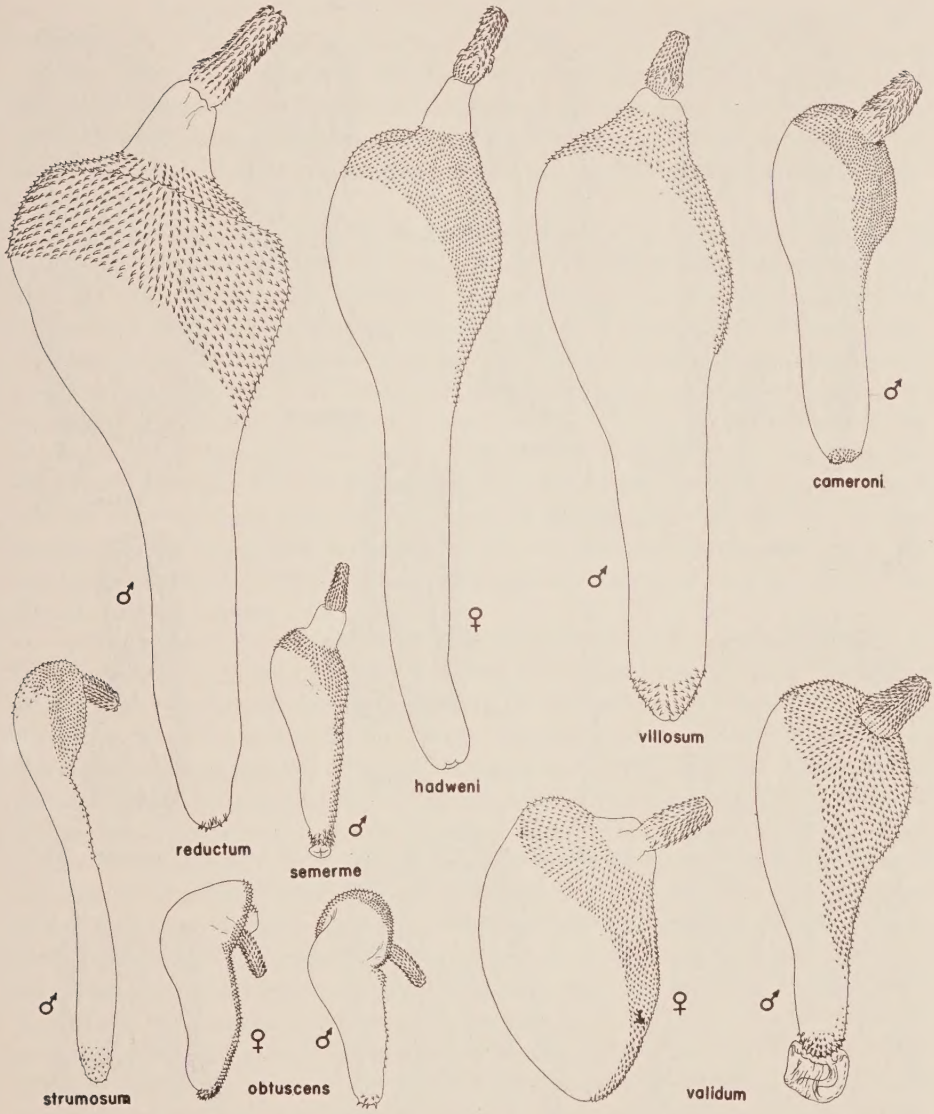
From time to time additional nominal species of *Corynosoma* from mammals of Europe have been included in the literature but usually these can be recognized as synonyms of *C. strumosum*. However, one species was suggested which seems to have the claim for distinctness. This is *C. reductum* (= *E. reductus*) that von Linstow (1905) described inadequately from immature worms taken by a Russian polar expedition. This species was often mentioned subsequently in the literature and is occasionally cited as a third species of *Corynosoma* from mammals of the northern hemisphere. However, no one has until now discovered additional representatives, so that the brief description of the immature individuals which served as the basis for the original description contains the only criteria available for differentiating this species from either *C. strumosum* or *C. semerme*. In his early work on ACANTHOCEPHALA of the arctic realm, Meyer (1931), relying wholly upon von Linstow's published observations, failed to deduce a single valid point of distinction between *C. reductum* and the other two species.

In the meantime, it had become common practice among European investigators to identify all mammalian corynosomas as either *C. strumosum* or *C. semerme*, depending upon whether the trunk spination is uninterrupted along the entire ventral surface of the body (*C. semerme*) or terminates anterior to the group of genital spines (*C. strumosum*). This all too simple means of differentiation seemed to have particular value because it could be applied to immature specimens, with introverted proboscides, encysted in the bodies of fishes serving as the second intermediate host.

A willingness to assume identity between American and European species of ACANTHOCEPHALA led to the early belief that the species of *Corynosoma* found in American mammals must be identical with those of Europe. Furthermore, this belief seemed to offer excuse for not undertaking the laborious task of autopsying the larger marine mammals. This was the status of the program of study of the taxonomy of ACANTHOCEPHALA of marine mammals when the present investigation was begun.

Numerous colleagues have cooperated in furnishing the collections upon which this study has been based. A complete list of these collaborators will be given in the definitive monograph on the ACANTHOCEPHALA OF NORTH AMERICAN MAMMALS which is in preparation and from which this study is a condensation of one section.

As the large quantities of new material began to pour into the laboratory, the macroscopic sorting of collections began to create an impression that the individuals could be segregated into groups having similar external appearance (Plate I). When these preliminary groupings were studied in detail it was discovered that more subtle morphological features which reflect specific differences are discernible in each of the groups (Plate II). Varying features which had earlier been interpreted as evidence of wide individual variability were often demonstrated to represent dis-



EXPLANATION OF PLATES

PLATE I. External features of eight of the nine species of *Corynosoma* encountered in mammals of North America. All drawings at identical magnification. In instances of conspicuous dimorphism, both sexes are figured. Drawings prepared by Charles A. McLaughlin, scientific artist in the Department of Zoology, University of Illinois.

continuous segments within the over-all range of the varying character. Unfortunately, for most of the units thus segregated as presumptive species, host specificity is not sharply fixed so that biological data do not fully support the morphological findings. As a consequence of detailed study and comparisons of measurements of critical features, *C. strumosum* and *C. semerme* were both recognized as clearly defined species in the North American fauna, often in the same hosts that have been

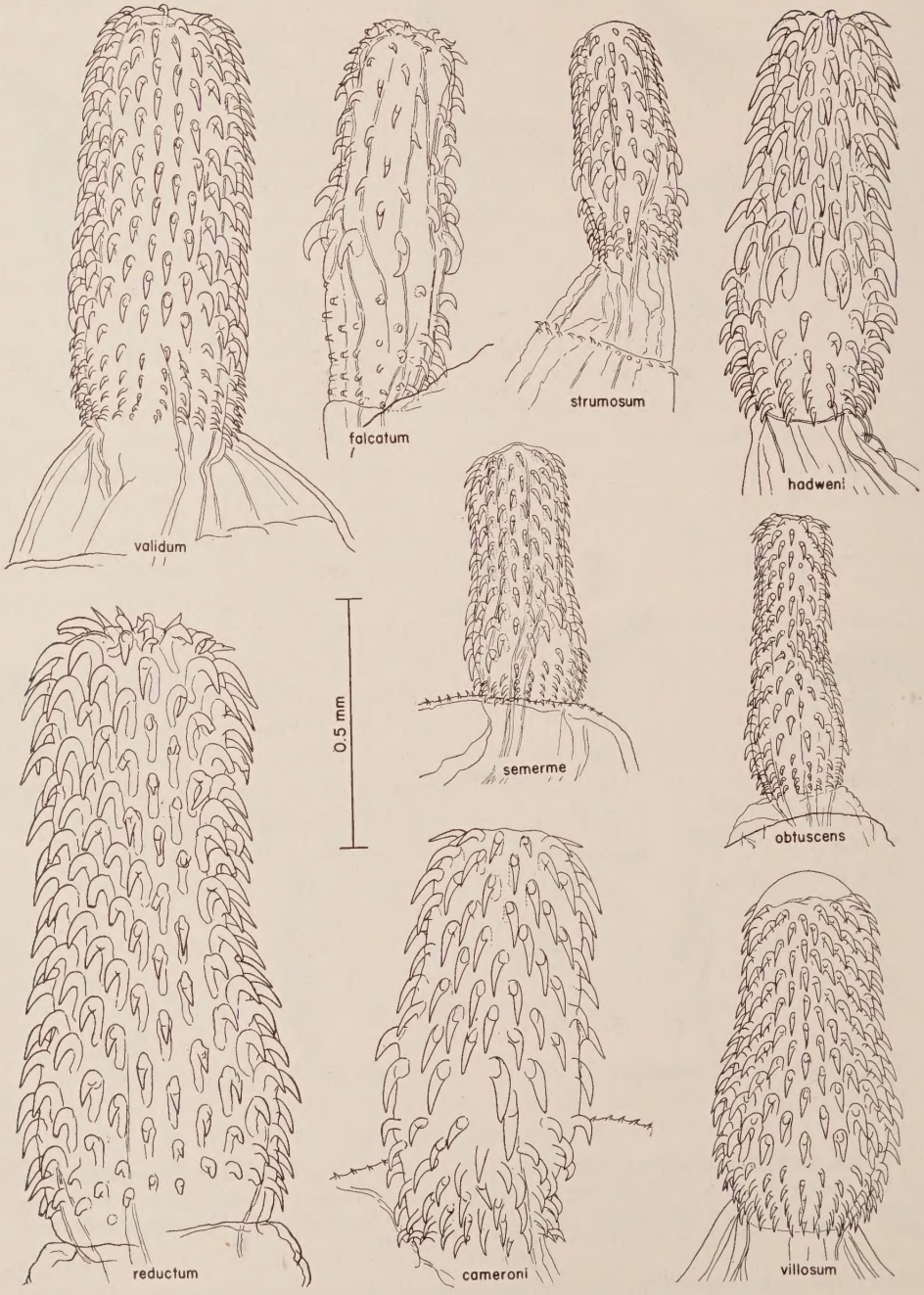


PLATE II. Proboscides of the nine species of *Corynosoma* from North American mammals, all drawn to the same scale for immediate comparisons of proboscis shape and size and for details of form and arrangement of the hooks. The following species are previously undescribed: *C. validum, falcatum, hadweni, cameroni,* and *villosum.*

recorded in Europe. When this American material was compared intimately with specimens from Europe it became possible to formulate a satisfactory concept of *C. strumosum* and *C. semerme,* including for the first time detailed information on the range in size of the proboscis, of the proboscis hooks, embryos, and body spines. With the incorporation of these features in the diagnoses of the species it is no longer necessary to depend upon esoteric information for the differentiation of species.

A group of specimens with inordinately large proboscides were at first segregated as possibly representing unusually "prosperous" individuals of *C. strumosum,* from an especially favorable host. Detailed studies showed that the size range of the proboscis is discontinuous with that characteristic of *C. strumosum* and that the pattern and sizes of individual hooks are clearly different. In spite of the scanty information available concerning *C. reductum,* this American material shows close agreement with the original description by von Linstow (1905). On the basis of the newly identified material, a relatively comprehensive diagnosis of *C. reductum* has been made possible. The full diagnosis will be given in the forthcoming monograph but the drawings here presented will serve to differentiate this species. In consequence of the recognition of this species in the American fauna, all three of the valid species recorded from European mammals are known to be duplicated in the North American fauna.

At this point in the analysis of the collections, there yet remained several lots of material which could not be included under any of these three concepts. Extended studies and comparisons finally resulted in the recognition of five additional new species apparently peculiar to the North American arctic and sub-arctic realms. Previously a single species, *C. obtuscens* Lincicome (1943), had been described as peculiar to the American fauna. Thus in a total of nine clearly defined species of *Corynosoma* encountered in North American mammals, six appear to be restricted to this continent while three are circumboreal in distribution. The writer has no satisfactory hypothesis to explain why speciation in *Corynosoma* has been so active in the western hemisphere while it has remained relatively static in the immediately contiguous eastern hemisphere. However, this is in harmony with the conditions previously mentioned for the family NEOECHINORHYNCHIDAE (Van Cleave, 1949; Van Cleave and Bangham, 1950) which has undergone marked evolutionary change at both specific and generic levels along with the evolution of the distinctive fish-fauna of North America. There has been no comparable degree of speciation in European fishes. The comparisons between the continental distribution and speciation in *Neoechinorhynchus* and *Corynosoma* extend still further. While each of these genera has at least one species which is widely distributed in both hemispheres (Van Cleave and Lynch, 1950; Van Cleave, this paper) there are additional species in each genus which are peculiar to the North American fauna. That this observation is not attributable to the application of different standards for species concepts is borne out by the fact that the present writer has examined representative collections of both genera concerned from European hosts and has found no evidence of diversification of species in the European fauna comparable to that which is so conspicuous in the American fauna.

It is the object of this preliminary report to present diagnoses of the five new species of *Corynosoma* found in North American mammals. Full biological, mor-

phological and historical considerations will be included in the monograph which is under preparation.

Only those illustrations which are of immediate value in diagnosis and differentiation of the species are included in this report. These are presented as a series of general habitus drawings (Plate I) showing external appearance of eight of the species, all at identical magnification, and detailed drawings of the proboscides (Plate II) for all nine species. The latter, which are all to the same scale, show relative size of the proboscis and the distinctive patterns of hook arrangement.

All types and study series are in the collection of the writer, in Urbana, Illinois, pending ultimate distribution of paratypes to other collections.

Corynosoma strumosum (Rudolphi, 1802)

Synonyms: *Corynosoma osmeri* Fujita (1922) and *C. ambispinigerum* Harada (1935) are regarded as direct synonyms of *C. strumosum,* in addition to the species recognized by Meyer (1932).

Material.—In the present study, considerably more than two hundred specimens of *C. strumosum* have been studied critically and compared with specimens from European collections. The type material has not been available.

On the basis of this extensive series, a comprehensive diagnosis of the species has been made possible. The full account, including details of distribution and hosts, will be given in the definitive monograph while in the present report the drawings show the morphological features essential for identification.

Corynosoma semerme (Forssell, 1904)

Material.—In the present study 70 specimens of *C. semerme* from North American hosts have been studied and compared with individuals from northern Europe. While the types have not been available, the collection of the writer contains six specimens from Finland which had been identified by A. L. Forssell, author of the species. These were obtained by exchange from the Helsingfors Museum through the courtesy of K. M. Levander.

Morphological features essential for recognition of this species are presented in the drawings accompanying this report. Detailed diagnosis will be given in the final monograph.

Corynosoma reductum (von Linstow, 1905)

Synonym: *Echinorhynchus reductus* von Linstow, 1905

In 1905, O. von Linstow presented a most unsatisfactory and incomplete diagnosis for a species, now recognized as a member of the genus *Corynosoma,* taken from *Phoca hispida* (= *P. foetida*) of West Taimyrland by the Russian Polar Expedition, 1900–1903. Only small, immature individuals were recorded. Since that time there is no direct evidence that any subsequent worker has ever recognized this species on the basis of specimens encountered. In lists of species and in faunal lists the name is occasionally mentioned (Railliet and Henry 1907, Porta 1909, Meyer 1931, 1932, *et al.*) but nowhere in the literature is there any information supplementing the sketchy observation of von Linstow.

Material.—The original material of *C. reductum* has not been available for study. The extant descriptions are so incomplete that only a few highly distinctive features,

such as the inordinately large proboscis, are available to make the species recognizable. Thirty-six individuals from North American hosts have served as the basis for formulating a redescription of *C. reductum*. The drawings accompanying this preliminary report are sufficient for recognition of this distinctive species, pending publication of a comprehensive diagnosis.

Corynosoma obtuscens Lincicome, 1943

This species was described by Lincicome (1943) from specimens taken by C. M. Herman from the California sea lion at the San Diego Zoological Garden. On superficial examination, a female of this species might be mistaken for *Corynosoma semerme*. *C. obtuscens* provides a most interesting intermediate condition, in that trunk spines of the female (Plate I) continue uninterruptedly to the posterior extremity as in *C. semerme* while in the male the trunk spination is interrupted, leaving an unspined zone of the hind-trunk anterior to the genital spines.

Material.—Three paratypes of *C. obtuscens* in the collection of the writer have served as the direct basis for identification of five immature specimens of this species taken from cysts in the viscera of the leopard grouper (*Mycteroperca pardalis*). The fish intermediate host was obtained from commercial fishermen operating in the vicinity of Mazatlan, off the west coast of Mexico.

Corynosoma validum n. sp.

Specimens taken in considerable numbers by Drs. Robert Rausch and E. L. Schiller from the Pacific walrus (*Odobenus divergens*) and from the bearded seal (*Erignathus barbatus*) have the proboscis of very unusual shape and the body of most distinctive form. The proboscis is almost perfectly cylindrical (Plate II) and is frequently nearly one-fifth the length of the entire worm. In body form there is distinct sexual dimorphism. While the male has a short, tapering, hind-trunk, not sharply set off from the fore-trunk and not as long as the fore-trunk, the body of the female is wholly devoid of any narrowed region at the posterior end. In the females the trunk is so highly inflated that the dorso-ventral diameter is often more than one half the length of the entire trunk and a bluntly rounded point is all that might possibly be considered as the equivalent of the hind-trunk so characteristic of all other members of this genus.

Material.—A total of 192 permanent whole-mounts of distinctive *C. validum* form the basis for the following specific diagnosis. Of these 89 are designated as types.

Diagnosis.—Body of female pouch-like, without attenuated posterior extremity, from 3.50 to 4.60 mm. long, with maximum dorso-ventral diameter of 1.80 to 3.20 mm.; males 3.90 to 5.40 mm. long with maximum diameter of 1.80 to 2.70 mm., the posterior portion of trunk reducing rapidly to a diameter of 0.35 to 0.46 mm. near the posterior extremity, especially in males with extroverted bursae. Neck short, diminishing rapidly from the diameter of the trunk to that of the base of the proboscis. Proboscis of both sexes cylindrical, that of female 0.8 to 1.0 mm. long by 0.34 to 0.40 mm. wide; of male 0.7 to 0.8 mm. long by 0.27 to 0.35 mm. wide. Proboscis armed with 22 or 24 longitudinal rows of 13 to 16 hooks each, of which the proximal 5 or 6 of each row are small, relatively crowded, and without recurved roots; anterior 9 or 10, with rooted hooks, not varying greatly in length but increasing gradually in diameter from tip toward the base of the proboscis; none of the hooks conspicuously enlarged, in females commonly about 0.079 mm. long by 0.026 mm. thick where the thorn joins the root, in males about 0.064 to 0.069 mm. long.

Trunk spines of female extending almost entire length of the body ventrally but only to the

region of maximum diameter dorsally, often each spine is surrounded by a small, rounded cuticular papilla; in males the spines extend along the ventral surface to a point only a short distance posterior to the hind margin of the testes, much of hind-trunk devoid of spines except for the genital spines on the area immediately adjacent to the genital pore. Largest trunk spines usually 0.035 to 0.053 mm. long in females, those of males usually a little shorter, 0.032 to 0.044 mm. Genital spines of males 0.035 to 0.053 mm. long and 0.010 to 0.014 mm. wide; ventral spines nearest female genital orifice 0.032 to 0.053 mm. long, commonly not reaching the immediate vicinity of the aperture. Genital spines of males often completely withdrawn into the introverted genital vestibule.

Proboscis receptacle in males often reaching backward into the region of the cement glands; in female often extending through more than half the length of the trunk. Lemnisci broad, flat, lateral edges usually rolled. Shelled embryos in bodies of gravid females 0.090 to 0.116 mm. long by 0.022 to 0.032 mm. wide.

Intermediate hosts unknown.

Definitive hosts—The Pacific walrus (*Odobenus divergens*) and unidentified seals in Alaska from St. Lawrence Island, Point Barrow, Kotzebue and Wainwright. All available records restricted to North America.

Types: Holotype female (VC4355.) from the Pacific walrus (*Odobenus divergens*), Wainwright, Alaska, August 1949, collected by Robert Rausch. Allotype male (VC 4429.6) from same host species, St. Lawrence Island, Alaska, April 1950, collected by Robert Rausch. Paratypes from same host species as holotype and allotype and also from bearded seal (*Erignathus barbatus*) VC 4309, taken by Robert Rausch at Point Barrow, Alaska.

Comparison.—*C. validum* differs from all other described species of *Corynosoma* in the shape of the body, which shows marked sexual dimorphism, the body of females having no cylindrical hind-trunk and being spined to a short distance anterior to the genital pore. The cylindrical proboscis without basal enlargement, is likewise distinctive.

Corynosoma villosum n. sp.

Several collections of *Corynosoma,* primarily from Steller's sea lion (*Eumetopias jubata*) from various islands in the Bering sea, are of uniform appearance and fail to agree in fundamental details with any other member of the genus. These are here recognized as a new species which is described under the name *Corynosoma villosum.*

Material.—*C. villosum* is one of the most abundantly represented species of the genus *Corynosoma* included in the present study. More than 200 stained permanent mounts have been studied in detail and from this long series 83 of the best specimens have been selected as critical material.

Diagnosis.—Females 6.40 to 8.40 mm. long by 1.78 to 1.85 mm. in maximum diameter; males from 3.50 to 6.35 mm. long by 1.36 to 1.60 mm. in maximum diameter. Fore-trunk somewhat inflated but not sharply set off from the plump hind-trunk, the union of the two often recognizable as a gradual merging rather than a sudden change in diameter. Anterior end of fore-trunk commonly in the form of a truncated cone, merging into the neck from which it is distinguishable by the fact that the narrowed fore-trunk bears spines. Hind-trunk of somewhat varying width, in females from 0.46 to 0.92 mm., in males from 0.42 to 0.69 mm. Neck short, about 0.17 mm. long. Trunk spines restricted to anterior end of fore-trunk and extending its entire length ventrally but dorsally reaching only to about the level of the maximum diameter. Each spine tapering to a practically straight point; in females 0.029 to 0.041 mm. long by 0.005 to 0.008 mm. wide, in males they may reach 0.053 by 0.011 mm. Genital spines apparently lacking in some adult females, very prominent in some young females and in males; widely scattered over genital extremity, in some individuals tending toward sigmoidal form, in other flat and broadly triangular, 0.044 to 0.053 mm. long by 0.012 to 0.019 mm. wide.

Proboscis broadly vase-shaped, expanded in basal third, in females 0.69 to 0.76 mm. long by about 0.346 to 0.448 mm. in maximum diameter, 0.208 to 0.230 mm. wide in anterior region and approximately the same diameter at the base. Dimensions of proboscis of males only slightly smaller than in females. Distal tip of proboscis often tipped with a smoothly rounded hyaline cap (see Plate II) extending about 0.058 mm. beyond the most anterior hooks. Arma-

ture consists of 22 to 24 longitudinal rows of 12 or 13 hooks each, of which the basal 4 to 6 are simple, thorn-like, without recurved roots and closely set in the longitudinal rows. Anterior hooks not showing marked gradation in length but with gradual increase in width of the thorn from the tip posteriorly. None of the hooks inordinately enlarged, the roots about the same length as the projecting thorn. Largest hooks of females 0.069 to 0.079 mm. long and about 0.027 mm. in width at the bend where thorn and root join; largest hooks of males 0.058 to 0.061 mm. in length.

Edge of genital pore of female slightly elevated as a lip-like ring, the swollen muscular vaginal sphincter filling the body cavity in the region of the pore where the body wall is very thin.

Testes of males ellipsoidal, extending into the posterior region of the fore-trunk, diagonally situated, reaching anteriorly to the level of the posterior end of the proboscis receptacle. Six clavate cement glands follow testes immediately, each about twice as long as broad.

Mature embryos within body cavity of gravid females 0.098 to 0.140 mm. long by 0.024 to 0.032 mm. wide with a small rounded expansion of the membranes at each pole.

First and second intermediate hosts unknown.

Definitive hosts: Type host Steller's sea lion (*Eumetopias jubata*) from various islands off the coast of Alaska. Also from the fur seal (*Callorhinus alascanus*), Pribilof Islands, and from undetermined species of seals and the sea otter (*Enhydra lutris*) of Alaska.

Types: Holotype male (VC 4443.1b) and allotype female (VC 4443.2a) from Steller's sea lion (*Eumetopias jubata*), St. Lawrence Island, Alaska, collected by E. L. Schiller, Aug. 1950. Paratypes from the same host species and same locality (VC 4443, VC 4444) as well as from East Cape, Amchitka, Aleutian Islands (VC 4570) collected by Robert Rausch, April 27, 1951; and from St. Paul Island of the Pribilof group collected by W. L. Jellison (VC 4583), Sept. 8, 1951.

Comparisons.—*C. villosum* differs from all other species of the genus *Corynosoma* in general shape and size of the body and shape, size and armature of the proboscis. The proboscis in shape comes nearest to that of *C. reductum* but that of *villosum* is much smaller although it carries more and smaller hooks in each longitudinal row than does that of *C. reductum*. The genital spines are much larger than those found on *C. strumosum*.

Corynosoma cameroni n. sp.

Professor T. W. M. Cameron submitted to the writer a series of collections of *Corynosoma* brought together by the staff of the Institute of Parasitology of Macdonald College from several autopsies of the white whale, *Delphinapterus leucas*. According to a preliminary report by Lyster (1940), only those white whales from the Gulf of St. Lawrence were infected by ACANTHOCEPHALA while a single individual from Baffin Island, another from Ellesmere Island, and yet another from Southampton Island were free from *Corynosoma*. Lyster (1940: 403) identified the specimens from the white whale of the Gulf of St. Lawrence as *Corynosoma strumosum*. The materials which the present writer has examined from the same collections do not conform to the concept of *C. strumosum* in shape or proportions of the body or in shape and armature of the proboscis. In a long series of very poorly preserved individuals there are but a few which show the proboscis clearly and these agree with the specimens with introverted proboscis in distinctive features of the body size, shape and proportions. A new species is recognized for the material from the white whale of the Gulf of St. Lawrence under the name of *C. cameroni*.

Material.—*C. cameroni* is based upon a study of 39 stained permanent mounts all of which are included in the type series.

Diagnosis.—Body in both sexes short and plump, from 2.50 to 3.60 mm. long by 0.90 to 1.60 mm. in maximum dorso-ventral diameter. Hind-trunk often no longer than fore-trunk, the former with bluntly truncated termination and approximately about one-half the diameter

of the fore-trunk. With no conspicuous constriction dividing the fore- from the hind-trunk. Trunk spination not extending posteriorly much beyond the fore-trunk on the ventral surface and reaching only a short distance along the dorsal surface. Trunk spines small, sigmoidal, about 0.026 to 0.035 mm. long with a diameter of 0.008 to 0.014 mm., occasionally with a basal portion directed anteriorly at a right angle to the projecting point but more often the proximal region is wide, narrowing without conspicuous bending except for a definite backward bend near the tip. Genital spines lacking in immature females; hence their absence is not due to removal with the shedding of the copulatory cap; in males comprising a large number of closely set spines, often introverted into the genital vestibule; commonly 0.026 mm. long by 0.008 mm. wide.

Neck short, in all available specimens inturned around the base of the proboscis in the anterior end of the fore-trunk. Proboscis sub-cylindrical without conspicuous enlargement in basal region; 0.70 to 0.90 mm. in length with maximum width of 0.32 to 0.41 mm.; armed with 16 longitudinal rows, of 9 to 11 hooks, in each of which the proximal 4 or 5 of each row are smaller than those anterior to them and are commonly crescentic in shape. Largest hooks 0.105 to 0.132 mm. long with a width of 0.038 to 0.046 mm. at the bend where the thorn and root meet; anterior hooks usually 0.055 to 0.095 mm. long by 0.022 mm. wide. Proboscis receptacle often reaching posteriorly into the hind-trunk.

No individuals of either sex fully mature.

Intermediate hosts unknown.

Definitive host, *Delphinapterus leucas,* the white whale, in the Lower Gulf of St. Lawrence, Province of Quebec, Canada.

Types: Holotype female (VC 3502.3) from white whale (*Delphinapterus leucas*) White Banks, Gulf of St. Lawrence, Quebec, August 7, 1938. Allotype male (slide VC 3505.4) from same host species and same locality, taken September 24, 1938. A series of paratypes, representing both sexes, from the same host species and same general locality.

Comparisons.—*C. cameroni* differs from all other species of the genus from mammals in the northern hemisphere in the shape of the short, thickset body with hind-trunk often no longer than the fore-trunk and commonly about one half the diameter of the fore-trunk. The proboscis is larger than that of all other species from mammals of the holarctic region except *C. validum, C. reductum* and *C. hadweni;* in shape as well as in number and differentiation of the hooks it is distinctly different from each of these. The proboscis is wider than that of *C. hadweni* and lacks the basal swelling; it is shorter and has fewer hooks than in *C. reductum;* and there is a much smaller number of hooks with greater differentiation of the hooks when compared with *C. validum.*

Corynosoma hadweni n. sp.

The first large number of specimens of the genus *Corynosoma* from seals which the writer had the opportunity to study were taken by the late Dr. Seymour Hadwen, at Unalaska Island of the Aleutian chain in Alaska, December 4, 1920 and January 21, 1921. The hosts were grey seals (*Halichoerus grypus*) and memoranda taken at the time of collecting indicated that some were from the small intestine and others were removed from fecal material of the hosts but the two groups were not kept separate. At first these were all regarded as representing a highly variable lot of *C. strumosum.* On the basis of body form and features of the proboscis and its armature two distinct species were segregated, leaving a residue that is clearly recognized as *C. strumosum.* One of the isolated lots is here taken as basis for the description of *C. hadweni.*

Material.—More than 150 permanent mounts of stained specimens of *C. hadweni* have been examined critically in the present study. Of this series 106 of the best specimens have been designated as critical type material.

Diagnosis.—Body moderately robustly enlongated, without difference between members of the two sexes. Enlarged fore-trunk about three-eighths the length of the entire trunk, its front end fairly evenly rounded, ovoidal in shape with the largest diameter anteriorly, the dorsal sur-

face somewhat more inflated than the ventral; posteriorly tapering to meet the diameter of the nearly cylindrical hind-trunk which is only about one-fifth to two-fifths the width of the fore-trunk. Total length 6.00 to 8.25 mm. with maximum dorso-ventral diameter of 1.43 mm. in males and 1.43 to 2.50 mm. in females. Trunk spines not conspicuous, along ventral surface usually not extending posteriorly much beyond the swollen fore-trunk and dorsally reaching only a short distance from the anterior extremity of the trunk; largest 0.026 to 0.046 mm. long by 0.008 to 0.014 mm. wide. Genital spines entirely separate from trunk spines, 0.024 to 0.035 mm. long by about 0.010 mm. wide, somewhat sigmoidal in form, often entirely obscured.

Neck fairly long, narrow, a truncated cone approximately as long the the proboscis. Proboscis with a fairly conspicuous enlargement of the basal third, carrying hooks much larger and heavier than on rest of proboscis. Proboscis length 0.84 to 0.93 mm.; with maximum diameter of 0.30 to 0.37 mm.; commonly about 0.23 mm. in narrowed anterior third. Armed with 16 longitudinal rows of 10 or 11 hooks each, of which the proximal 5 or 6 are simple, thorn-like, fairly closely crowded in the row and as a series rather widely separated from the greatly enlarged hooks anterior to them. Anterior hooks progressively increasing in diameter from the anterior tip of proboscis, with conspicuous roots usually about the same length as the projecting thorn. Hooks near distal tip 0.079 to 0.104 mm. long with a dorso-ventral width of 0.004 to 0.016 mm. at the bend where thorn joins the root; largest hooks 0.105 to 0.150 mm. long with width of 0.026 to 0.041 mm.; basal hooks with the distal one-third or one-half bent posteriorly, almost at a right angle to the basal part, straight line measurement from tip to root 0.046 to 0.061 mm. with diameter of 0.005 to 0.011 mm.

Testes about twice as long as wide, the anterior one reaching into the cavity of the fore-trunk. Cement glands very long, tubular.

Embryos within bodies of mature females 0.093 to 0.115 mm. long by 0.020 to 0.035 mm. wide, with rounded internal prolongation at each pole.

First intermediate host unknown.

Second Intermediate Host.—Cyctacanths removed from visceral cysts of the smelt, *Osmerus mordax*, collected by Dr. Marvin C. Meyer, Maine.

Definitive hosts.—The grey seal (*Halichoerus grypus*), Unalaska Island, Aleutian Chain, Alaska, taken in December and January by the late Dr. Seymour Hadwen; ringed seal (*Phoca hispida*), Point Barrow, Alaska taken in April and May by Dr. Robert Rausch; unidentified seals of the genus *Phoca*, St. Lawrence Island, Alaska in April and May and at Katzebue, Alaska in May by Dr. Robert Rausch.

Types: Holotype female (VC 4311.1) from ringed seal (*Phoca hispida*) taken at Point Barrow, Alaska by Robert Rausch, May 5, 1949; allotype male (VC 4432.1) from undetermined seal taken in Alaska by Robert Rausch, May 1, 1950. Paratypes of both sexes from various other seals in Alaska and from the mouth of the Clyde River, Baffin Island.

Comparisons.—*C. hadweni* most closely resembles *C. strumosum* and *C. reductum*. It differs from both of these in many respects of which the most readily observable are the size, shape and proportions of the body and the size of the proboscis and the number and sizes of the individual hooks.

Corynosoma falcatum n. sp.

Some specimens mixed with *C. strumosum* and *C. hadweni* from the grey seal (*Halichoerus grypus*) show marked peculiarities in the shape and size of the proboscis and the form of the proboscis hooks. The first one of these under observation was regarded as a teratological specimen, but when several having the same appearance were discovered it became evident that a new species would need to be recognized and to this concept the name *C. falcatum* has been applied.

Material.—A total of eight specimens of *C. falcatum* have been examined in the present study. These constitute the type material.

Diagnosis.—Body moderately robust, with inflated fore-trunk and practically cylindrical hind-trunk, the latter bluntly rounded at its posterior extremity. Body shape not conspicuously different in the two sexes but females larger than males. Total length of females 6.00 to 7.27 mm., maximum width of fore-trunk 1.25 to 1.97 mm.; males 4.60 to 5.30 mm. in length by 1.07 to 1.25 mm. in maximum width; in largest females the hind-trunk is 0.40 to 0.57 mm. in diameter, in males about 0.23 to 0.40 mm. Trunk spination never conspicuously developed, faintly discernible

on front end of fore-trunk but no spines on the hind-trunk. Genital spines not observed in either sex. Neck short. Proboscis frequently cylindrical with but a slight swelling just posterior to the middle, 0.690 to 0.865 mm. long by 0.208 to 0.300 mm. in maximum diameter; armed with 14 longitudinal rows of 10 or 11 hooks each, of which the basal 4 or 5 (6 in some specimens) are small and of very irregular shape, often lacking sharp point, not crowded in the row. Largest hooks 0.075 to 0.115 mm. in length, distinctly faciform or sickle-shape, in some instances as much as 0.026 to 0.041 mm. in width at the bend where thorn joins root; at times the tip forming a nearly closed loop or short tip-region bent at almost a right angle to the enlarged basal part of the thorn. Hooks sparsely distributed over the proboscis, many lacking distinct root and often deformed in shape. Largest hooks at level of maximum diameter of proboscis or anterior to it on the anterior slope leading to the enlargement.

Male reproductive organs confined to the cylindrical portion of the hind-trunk. Testes slightly longer than broad, considerably overlapping one another, not reaching to the level of the proboscis receptacle. Cement glands short, pyriform, crowded immediately behind testes. Embryos in body of fully gravid females 0.069 to 0.093 mm. long and 0.019 to 0.024 mm. wide, with a small, rounded expansion of inner membranes at each pole.

Intermediate hosts unknown.

Definitive host, the grey seal (*Halichoerus grypus*), Unalaska, Alaska, collected in December and January.

Types: Holotype female (VC 2637.16), allotype male (VC 2637.17) and six paratypes, all from grey seal (*Halichoerus grypus*) taken at Unalaska, Dec. 4, 1920 by Seymour Hadwen.

Comparisons.—*C. falcatum* differs from all other species of the genus in the number and peculiar shape of the proboscis hooks and in deformity of the basal hooks in each row. It differs from *C. strumosum* and *C. hadweni,* from the same host species, in that the length of the proboscis of *C. falcatum* is about intermediate in length between them, with but rarely any individuals intergrading in length. There are also fewer longitudinal rows of proboscis hooks in *C. falcatum* than in the other two.

Unidentifiable species.—After the foregoing species of *Corynosoma* had been recognized, there remains an irresolvable residue of unnamed materials in the collection of the writer. Much of this is doubtless material of the other species which fails to show distinctive specific characters, probably because of poor preservation. In several lots of specimens no proboscis is observable, either because it is always completely introverted due to improper treatment before preservation, or because the worms were forcibly pulled from the host intestine, severing the body of the worms from their proboscides which were left buried in host tissues.

One clearly new species is undescribed because it is represented by a single individual and although the proboscis of that specimen is partially introverted the length if extruded would exceed that of any other species. This specimen is from the sea otter (*Enhydra lutris*) of Simeonof Island. Some later collector may secure material that will make description possible. In observable features this is radically different from *C. enhydris* which Afanas'ev (1941) described from the same host of the Commander Islands and also from *C. villosum* of the present article.

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THREE LERNAEID COPEPODS PARASITIC ON SOUTH INDIAN FISHES

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The three lernaeids described here belong to the genus *Lerneaenicus*. Wilson (1917) listed twelve species of this genus. Six more, (*L. cerberus* Leigh Sharpe, 1927; *L. hemirhamphi* Kirtisinghe, 1932; *L. gnavius* Leigh Sharpe, 1934; *L. gnathoricus* Leigh Sharpe, 1934; *L. seeri* Kirtisinghe, 1934; *L. savori* Yamaguti, 1939) as well as a new variety *L. sardinae* var *longicornis* Boudoin, 1918, have been added since. In the present paper, *L. hemirhamphi* Kirtisinghe, is described more fully than before and a brief note on its anatomy is added. The other two lernaeids, *L. nemipteri* and *L. stromatei* are new species which are described below.

Lerneaenicus hemirhamphi Kirtisinghe

(Figs. 1–8)

Host and record: Twelve small-sized gar fish (*Hemirhamphus far* Forsk), caught in February and September at Madras had one parasite each while two large fishes caught in October provided nine more.

Bionomics: Of seven dissected out of the hosts, three were buried in muscle, like most members of the genus but four had reached kidney or liver or stomach wall and two of these had caused tumors. (A) penetrated into the left side of the body, entered the body cavity in the region of the duodenum, curved under the stomach to the right side, turned upwards and running parallel to the right kidney buried its head into it from below. (B) took the same course as the former but pushed its head into the liver. (C) bored into the body wall in front of the anus, went forward very close to the peritoneal wall, curved backwards and upwards and sweeping outward round the deep lateral muscles, bent down close to the wall of the body cavity once more. (D) entered the body muscle on the left side and completed its course in them. (E) penetrated the dorsal side of the body and ran forwards and downwards through the muscles and ended close to the ligaments round the vertebral column. (F) pierced the body wall near the anus, entered the body cavity, bored through the kidney and ran dorsal to it below the vertebral column for some distance, entered the kidney mass again and ended in a tumor. (G) entered the right side of body behind the pectoral region, ran through the muscles into the body cavity and rested the head on the surface of the right kidney.

A scrutiny of the above cases will show that the parasites frequently bore, as if by genetic urgency, beyond sites where they can feed and fix themselves easily, till they acquire a certain length of neck characteristic of the species. Extensions beyond this length are probably induced by exigencies of securing food and fixation.

Most of the parasites examined were living though the host fishes were dead when brought to the laboratory. When dissected out and left in bowls of fresh sea water, they did not survive even one hour. Ceaseless peristalic contractions of the intestine were the unfailing indications of life. Timed with a stop-watch, these pulsations of the gut occurred at a rate of 80–85 per minute so that about five waves were seen travelling down the length of the gut at any time. As in other parasitic copepods, these were in both forward and backward directions. During the period of observation the direction was reversed every minute and a half, with quiescent intervals of about five seconds. When resuming, the contractions were more rapid than towards the close of each phase. Under high magnification, it was noticed that these contractions while disturbing the contents of the gut did not propel them.

Color: The body of the parasites, especially the genital segment and abdomen, appeared blood-red due to the fish blood contained in the wide gut and to four streaks of red color of the skin. The egg-strings were blue-green in color as also the egg-filled oviducts visible through the body wall.

Size: The length ranged from 2.9 cm. to 4.8 cm. owing to the varying lengths of the neck region of the different individuals. As can be seen from the table the genital segment and ab-

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domen also varied in a way which renders their relative proportions unsuitable for specific diagnosis.

External characters: The head, of the type form, is one and one-half times longer than broad but appears longer owing to the backward extension of the horns. The front end is smoothly rounded and is marked by the antennae as well as by a horse-shoe shaped cushion in front of the mouth. The three horns behind are short and rounded and frequently vary in size according to the location. The free thoracic segments are attached at right angles to the head in front of the horns. These taper down into the neck, the thinnest and longest part of the body. The neck widens into the genital segment which is ventrally grooved and ends in the slender abdomen. The egg strings mark the posterior limits of the genital segment and are thinner than the abdomen. The hind tip of the abdomen ends in two rounded prominences each bearing two stumps of setae.

Appendages: The first antenna is three jointed, long and tapering. It is pressed close to the surface of the head and bears twenty setae. The second antenna also is three jointed. It arises close behind the base of the first and is short, stout, erect and chelate. The proboscis is a large retractile tube stiffened by hoops of chitin. Beyond the distal chitin ring which bears a number of small spines, the proboscis extends as a flexible fringe supported by chitinous hairs. In all the specimens examined, the proboscis was retracted and the oral appendages could be easily seen through the wide opening. These consist of three pairs, of which the deepest and

Table showing the varying lengths of the different regions of the body

	A	B	C	D	E	F	G
Total length in mm.	36.1	56.5	47.6	39.2	42.5	35.5	28.9
Genital segment	5.8	6.6	7.2	7.3	6.7	6.1	6.2
Abdomen	7.4	9.0	7.8	5.8	6.4	3.9	6.5
Head	1.3	1.3	1.4	1.9	2.1	1.3	2.1
Neck	21.6	39.6	31.2	24.2	27.3	24.2	14.1

most posterior can be identified as the mandibles mentioned by Wilson (1917). The two more superficially situated anterior pairs were not mentioned by him. In describing the present species, Kirtisinghe (1932, p. 551 and fig. 6) noted these "two pairs of spines placed one behind the other." Leigh Sharpe (1934, fig. 4) figured a pair of spines other than the mandibles. Yamaguti (1939, fig. 177) sketched three pairs of appendages within the proboscis of *L. sayori* but his description leaves the identity of these in doubt. If the hind-most pair is taken as the mandibles which lie close to the mouth and labrum, the remaining two pairs may be accepted as the maxillae which have been shifted to a position anterior to that of the mandibles by the formation of the distal part of the proboscis tube. Such an enumeration of the appendages can only be confirmed by a study of the development. Close behind the basis of the proboscis tube are attached a pair of larger, three-segmented maxillipedes (Wilson's "maxillae"). Each has a long, stout recurved claw.

There are four pairs of swimming legs decreasing in size caudally. The first two legs are alike. The protopod is broad at the base with a deep groove dividing it distally into two tips, each of which bears a short claw and a two-jointed ramus. The proximal joint of each ramus bears one seta while the distal bears seven setae and a spine. The third and fourth legs are uniramous, with narrow and long protopods. The single ramus persists in only a few individuals and is folded back on the protopod. That of the third leg bears five setae and a spine while that of the fourth carries four setae and a spine.

Internal anatomy: The cuticle is stratified and of varying thickness. The body wall of the genital and abdominal region is more muscular than in *Cardiodectes anchorellae* or *Peniculus* spp. Several bundles of the muscles are attached to the lateral walls of the intestine which is far wider than in those species. Numerous dorso-ventral bundles occur in the region of the head. The histological structure of the gut and body wall is similar though the presence of large numbers of undigested red corpuscles within the intestine is noteworthy. The fat tissue is present around the intestine, but is not so well developed and compact as in the other species. The reproductive system is similar and consists of seminal reservoirs, cement glands and ducts as well as oviducts and a short ovary.

Lerneaenicus nemipteri n. sp.

(Figs. 9–16)

Host and record: On a single fish of the species *Nemipterus marginatus* C.V. (*Synagris bleekeri* Day) caught at Madras in February 1949, three females of this parasite were found attached together with their heads buried in the lateral muscles of the self side. As their nu-

merous branched horns were intertwined, it was possible to remove only one of the parasites in an unmutilated condition. All three bore egg-strings.

Color: The body was of a dark heliotrope tint and appeared almost black.

Size: The three specimens were about the same length, 19.6 mm. The head measured 2 mm., the neck 3.6 mm., the genital segment 6.5 mm., and the abdomen 7.5 mm.

External characters: The buried part of the parasite was short and straight. The possession of numerous branched horns aids this parasite in securing fixation, which handicapped as it is with a short neck, it would never achieve otherwise. The "head" is club-shaped. It is broad at the anterior end and tapers into the neck behind. It bears two whorls of branched horns, one behind the mouth and the maxillipede, and the other, in front of the free thoracic segments bearing the four pairs of legs. Where these whorls occur, the head appears swollen into nodes. Some of the horns are simple, while others are branched twice and thrice. Each horn is a long slender transparent process ending in a terminal bulb. The anterior whorl of horns is incomplete dorsally where two pairs of large swellings occur and meet medially. Between them are located the inconspicuous antennae. The frontal margin bears a pair of short stout processes. Each forks and protrudes forward bearing one or two smaller ventral processes. The two pairs of large rounded bodies and the two branched processes correspond to the attachment lamellae of *L. polyceraus* and *L. affixus.* At the base of the frontal processes, on the ventral side, is seen the short cylindrical proboscis. The deep-seated median eye also is visible ventrally. Behind the posterior circlet of horns, the free thorax narrows rapidly to the short neck which curves dorsally to join the genital segment. This part of the body is longer and nearly five times stouter than the neck. It is uniformly cylindrical and narrows into the longer abdomen. Small stubs of two setae are the only vestiges of the anal laminae. The egg strings are long and a fifth of the abdomen in thickness.

Appendages: The antennae, which have been shifted to a dorsal position by the exaggerated frontal lamellae, are hidden among them. The first antenna is slender, three-segmented, weak and curled. A few short spines are borne by the tip of the appendage. The second antenna stands upright but, being short, is hidden by the swollen lamellae. It consists of a powerful claw borne by a two-jointed stem. Within the opening of the proboscis can be seen the three pairs of oral appendages. As in *L. hemirhamphi,* they may be the mandibles, and the two maxillae. Below and behind the base of the proboscis are attached the maxillipedes. These have three articles, the terminal one of which is a stout piece drawn into a narrow sharp claw. The four pairs of thoracic legs appear inconspicuous owing to the rami being extremely aborted. The protopods are large and flat. The one-segmented rami are small and rounded. Each bears a single curved spine.

Relationships: The present form resembles *L. polyceraus* Wilson. in having two rings of horns, the horns being branched and in possessing the attachment lamellae. But the form of these lamellae, the whorls of horns being in front of the free thoracic region and the form of the 'head' appendages as well as the legs, mark the present form as distinct from it and the six species established subsequent to Wilson's key (1917). The present new species may be defined as follows:

Head club-shaped bearing two whorls of branched horns in front of the free thoracic segments. The attachment lamellae are modified into two pairs of swollen structures on the dorsal side and a pair of branched processes. The antennae are reduced and inconspicuous. The swimming legs have single-jointed, reduced rami.

Type host: Nemipterus marginatus C.V.

Location: Lateral muscles of body.

Type locality: Madras, South India.

Type specimens: The holotype female will be lodged in the Indian Museum, Calcutta. The paratypes will be in the author's collection.

Lernaenicus stromatei n. sp.

(Figs. 17–22)

Host and record: Eleven females were collected from as many small-sized *Stromateus niger* Bloch landed at Madras. Two of these were young forms, probably larvae just metamorphosed. As these show several features different from the adult, they are also described fully.

Habitat: Unlike most species of this muscle-infesting genus, the present species bored into blood vessels. The course of six parasites will serve to show the devious routes taken to their destinations. (A), 47 mm. long, entered through the nares, bored past the mesethmoid, palatine and vomer and running along the roof of the mouth cavity penetrated the ophthalmic artery and came to rest close to the pseudobranch. (B), 63 mm. long, pierced the edge of the operculum, travelling along the inside of the lower edge, and wandering in the tip of the lower jaw,

entered a branchial artery. (C), 44 mm. long, entered the cloaca, ran backwards along the skin and muscles of the body wall and came to rest in the femoral vein. (D) and (E), both 54 mm. long, pierced through the cloaca and bored their way forward along the ventral muscles and entered a branchial artery through the mouth floor. (F), 48 mm. long, bored through the skin in front of the caudal fin, reached the vertebral column and running between the neural arches to the opposite side, finally lodged in a vein in the muscles under the dorsal fin.

Size: The parasites dissected out in a complete condition ranged from 14.5 mm. to 63 mm. in length. It was remarkable, that in all the forms including the youngest, the head and the genital segment varied but slightly, whereas the neck and the abdomen varied a good deal in length. In D and E which are of the same total length (54 mm.) the neck measured 32 mm. and 30 mm. but the abdomen was 13 mm. and 15 mm. respectively while in A, B, C and F a neck of 25 mm., 37 mm., 21 mm. and 27 mm. was combined with an abdomen of 14 mm., 15 mm., 15 mm. and 12 mm. Therefore as in *L. hemirhamphi,* the relative lengths of the different regions of the body cannot be of much use in species diagnosis.

Color: Dirty white.

External characters: The head is stout, blunt-ended, cylindrical and slightly flattened above downwards. The breadth is two thirds the length whereas the height is slightly more than half the length. A dark heliotrope eye is found to the right of the middle line. The antennae also appear dislocated asymmetrically to the right side while the four free thoracic segments appear twisted slightly to the left of the median line. This free thoracic region is attached at right angles to the long axis of the head and tapers down to the "neck." The four segments of this region are indicated dorsally by furrows and ventrally by four pairs of swimming feet. The thread-like neck leads posteriorly into the genital segment which is four times thicker and is midventrally grooved. This uniformly cylindrical region is continued straight behind as the narrower, tapering abdomen. The hind limit of the genital segment is marked by a pair of egg strings and a pair of prominences. At the tip of the abdomen are two slightly raised areas bearing stumps of one or two setae. In immature forms the neck, the genital segment and the abdomen are of uniform thickness.

Appendages: The first antenna is extremely shortened, stout, and faintly marked into three segments. The spines are inconspicuous except on the middle joint. The second antenna arises posterior to the base of the first but extends in front and is supported by a semicircular thickening of the frontal area. The mandibles and the two pairs of maxillae are contained in the large tubular proboscis. The structure of the proboscis and the attachment of the oral appendages resemble those of *L. hemirhamphi.* The maxillipede is a three-jointed appendage whose base is attached close to the proboscis and is hidden by it.

Of the four pairs of thoracic legs, the first two are biramous. The first pair is turned outwards. The protopod is broad, conspicuously pigmented and deeply grooved. It bears two rami which are two jointed and bear six long setae. The second leg is turned inwards and slightly forward. The protopod is smaller than that of the first and bears rami with five setae. The third leg is smaller, uniramous and bears five setae while the fourth leg is the smallest and bears four setae.

Metamorphosed larva

(Figs. 23–28)

One of the fishes was infected by two very young parasites of which only one was removed in an unmutilated condition.

Size: The total length of the body was 14.5 mm. of which the abdomen measured 2.5 mm., the genital segment 8.0 mm., the neck 3 mm., and the head 1 mm.

Color: The entire body was whitish and transparent.

External characters: The anterior part of the body is definitely copepodiform in appearance. The head is long, conical, flattened above downwards and pointed in front. It is covered dorsally by a large carapace whose sides are folded down ventrally. A double median eye was conspicuous dorsally and was also visible laterally. The ventral surface was distinguished by a large prominent funnel-shaped proboscis, as well as by a large plate bearing numerous short backwardly directed spines. The recurved spines prevent the parasite from slipping backward while aiding forward movement. There are no horns. These are probably developed when the parasite has arrived at the adult stage and needs anchorage. The absence of a tough cuticular tunic round the buried part of the body is also noteworthy. This raises a doubt whether this thick sheath found around full grown adults is secreted by the host's tissues or whether it is formed of the cuticular skins moulted by the parasite. Though the tunic being formed of more than one coat, makes the latter explanation the more probable, yet it is likely that in the region of the head there is some secretion by the host as well.

The free thoracic segments, which are well marked, form but a slight angle with the 'head.'

The first segment is four-sevenths of the carapace in width and has a length one-fifth of its breadth. The second segment is nearly as broad but longer. The third and fourth segments are as long as the second but narrower. The rest of the body is as broad as the fourth free segment, there being no differences in thickness between neck, genital segment and abdomen. The tip of the abdomen is marked by two prominences carrying four anal setae each.

Appendages: The first antenna is long, cylindrical, tapering and three-segmented, bearing nearly twenty-seven long setae. Starting from close to the base of the first, the second antenna projects forward medially. As is in the adult, it is three-segmented but large and prominent. Proportionate to the cephalothorax, the proboscis is very large. It has the same form as in the adult but has a thick coiled glandular structure on its posterior aspect. The mouth is directed forwards between the mandibles. The maxillipedes are long, three-jointed and straight, the distal joint being a long tapering spine not so curved as in the adult.

The swimming legs are large and decrease in size posteriorly. The protopods are long and are held out conspicuously on either side of the slender, free thoracic segments. Their form and structure, however, resemble those of the adult. The first two are biramous and bear a spine and seven setae on each ramus while the last have only four setae and spines.

Relationships: While the present species resembles *L. longiventris* Wilson as well as *L. hemirhamphi* Kirtisinghe in its general apeparance, it is distinguished by the asymmetry of the front part of the body, the reduced first antennae, the grooves of the free thoracic segments, the form of the maxillipedes, the details of the structure of the proboscis and oral appendages, the genital prominence as well as the form of the swimming legs, especially the first. *Lernaeenicus stromatei* n. sp. may be defined thus: The cephalothorax and free thoracic segments twisted in opposite directions, attachment lamellae absent, the antennae reduced, and the first swimming leg turned forwards; the genital segment deeply grooved ventrally and marked posteriorly by prominences; the 'head' usually bores into blood vessels.

Type host: Stromateus niger Bloch.

Location: blood vessels of the body.

Type locality: Madras, S. India.

Type specimen: The holotype female will be lodged in the Indian Museum, Calcutta. The paratypes will be in the author's collection.

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Explanation of Figures

Plate I

Fig. 1. *Lerneaenicus hemirhamphi.*
Fig. 2. Ventral view of head.
AL: Attachment lamella. MH: Median horn.
F.A.: First antenna. Mxp: Maxillipede.
L: Legs. P: Proboscis.
LH: Lateral horns. SA: Second antennae.
Fig. 3. Second antenna.
Fig. 4. First antenna.
Fig. 5. Anal setae.
Fig. 6. Oral view of proboscis.
MD: Mandible. Mx2: Second (?) maxilla.
Mx1: First (?) maxilla. Mxp: Maxillipede.
Fig. 7. Swimming legs.
A: First leg. C: Fourth leg.
B: Third leg.
Fig. 8. Hind region of genital segment.
Fig. 9. *Lerneaenicus nemipteri* n. sp.
AL: Attachment lamellae. PWH: Posterior whorl of horns.
AWH: Anterior whorl of horns. SL: Swimming legs.
Fig. 10. The 'head.'
A: Dorsal view. ANT: Antennae.
B: Ventral view. P: Proboscis.
ALP: Attachment lamellae processes. SL: Swimming legs.
ALS: Attachment lamellae swellings.
Fig. 11. Proboscis oral view.
MD: Mandible. Mx2: Second maxilla (?).
Mx1: First maxilla (?).
Fig. 12. Antennae.
A: First antennae. B: Second antenna.
Fig. 13. Maxillipede, two views.
Fig. 14. Two swimming legs.
Fig. 15. Hind end of genital segment.
Fig. 16. Anal setae.

Plate II

Fig. 17. *Lerneaenicus stromatei* n. sp.
Fig. 18. A and B lateral view of 'head.'
E: Median eye shifted to right side. P: Proboscis.
FA: First antenna. PL: Posterior legs.
FL: First leg. SA: Both second antennae, seen in right side.
Fig. 19. Proboscis—oral view.
Mx1: First maxilla (?). Mxp: Maxillipede.
Md: Mandible. Mx2: Second maxilla (?).
Fig. 20. A. and B. Hind ends of genital segment and abdomen.
Fig. 21. The antennae.
FA: First antenna. SA: Second antenna.
Fig. 22. Swimming legs.
1: First leg turned forwards. 3: Third leg.
2: Second leg. 4: Fourth leg.
Fig. 23. Young form—metamorphosed larva—showing ventral view of head.
Fig. 24. Lateral view of head.
C: Carapace.
FA: First antenna. P: Proboscis.
Gop: Glandular organ of proboscis. RE: Right half of median eye.
L1–4: Four swimming legs. SA: Second antenna.
Mxp: Maxillipede. SS: Sternal spines.
Fig. 25. Anal spines.
Fig. 26. Dorsal view of Cephalothorax and free thorax.
Fig. 27. Oral view of proboscis.
Fig. 28. A. and B. First antenna and maxillipede.

Plate I

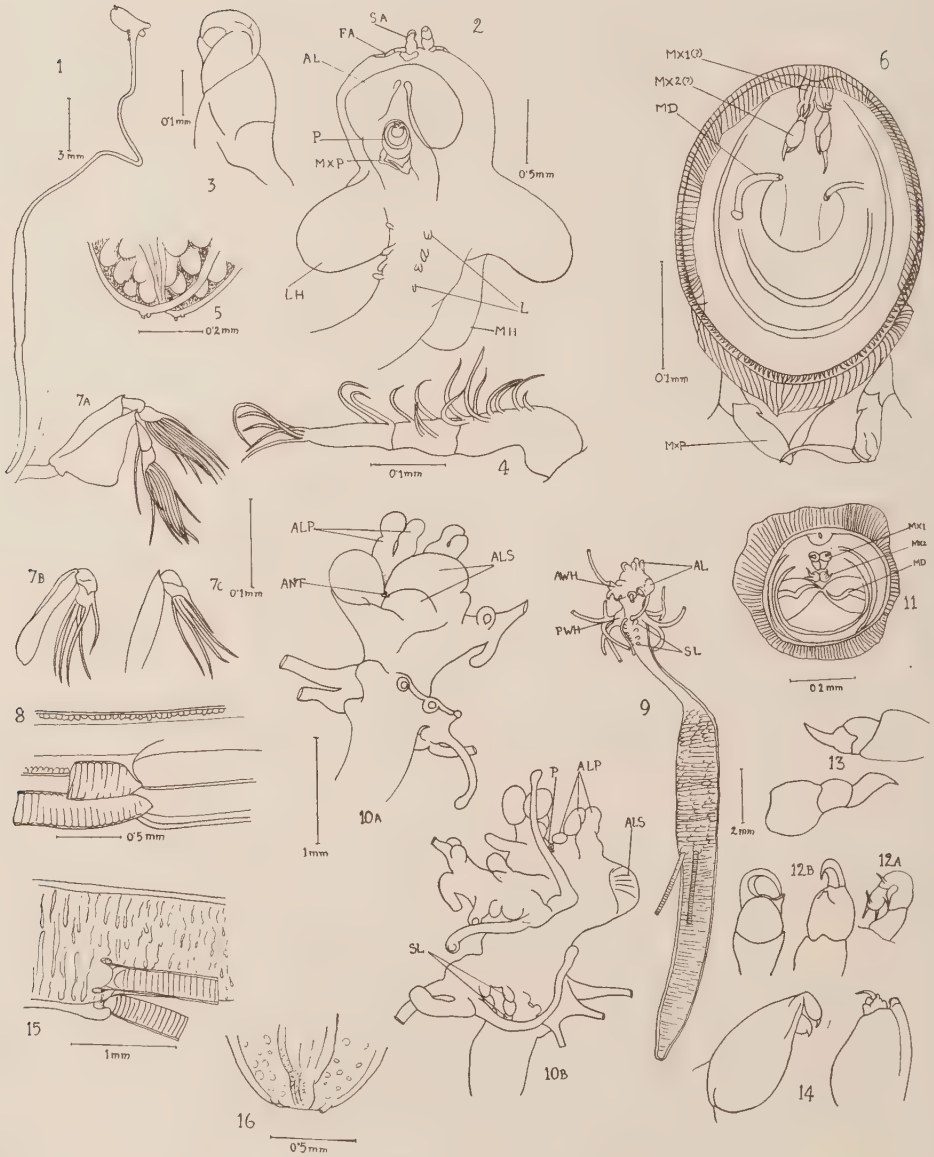
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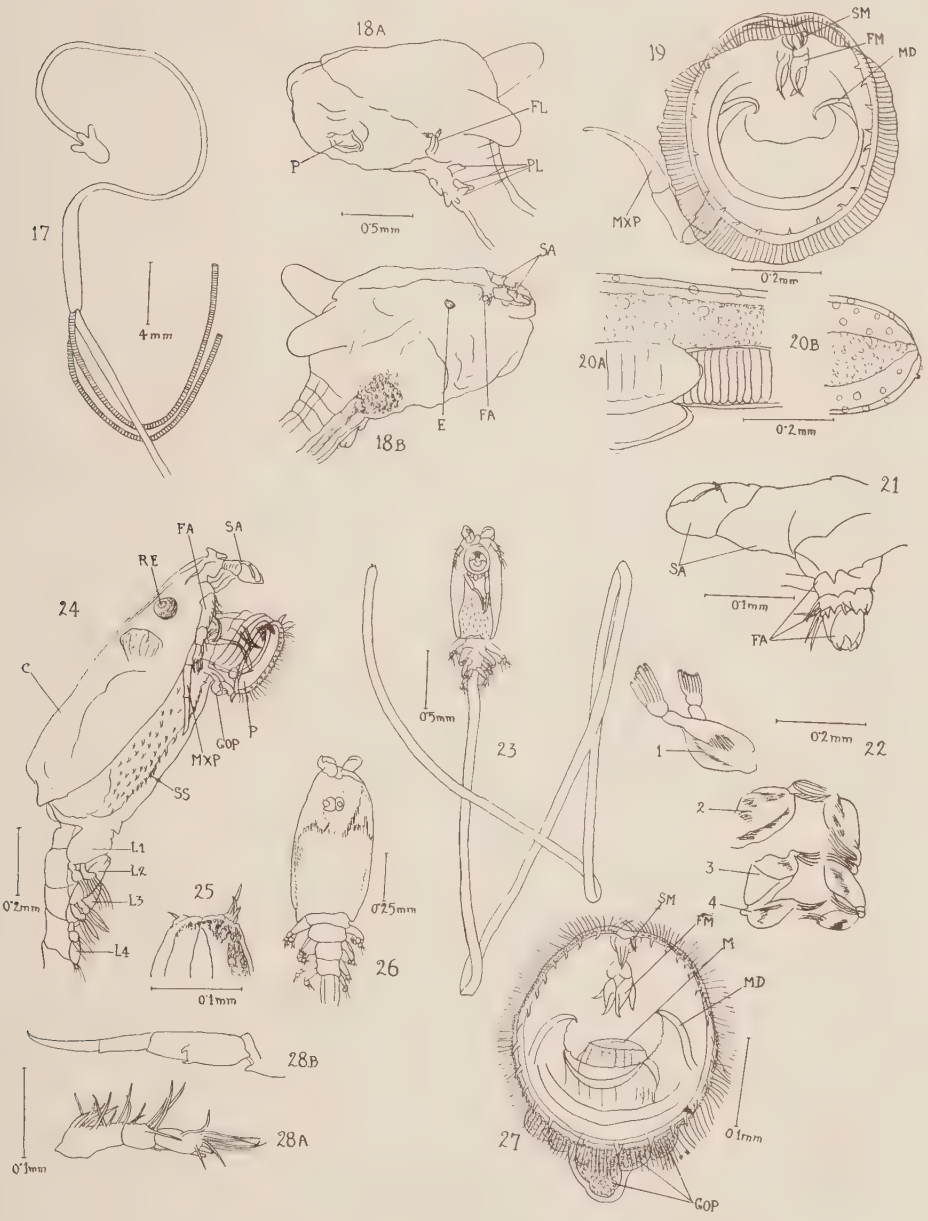
Plate II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BASILIA CALVERTI N. SP. (DIPTERA: NYCTERIBIIDAE) FROM THE INTERIOR LONG-LEGGED BAT

R. M. Fox and R. M. Stabler
Colorado College, Colorado Springs

Late in the afternoon of 1 September 1951, while fishing in Manchester Creek some eight miles north of Divide, Colorado, at an elevation of about 8,000 feet, one of us (R. M. S.) rescued a swimming interior long-legged bat (*Myotis volans interior*) which had inadvertently fallen into a beaver pond. Some 15–20 other bats were working the air over this pond. Later inspection revealed that the captured bat was parasitized by two flies, one male and one female, belonging to the group of wingless forms in the family Nycteribiidae. They prove to belong in the genus *Basilia,* and appear to be a new species, described below.

On 18 June 1952 two similar bats were captured in the Stabler barn (elevation 6,300 feet) a few miles north of Colorado Springs. Both were infested with the same species of *Basilia* that had been found on the Manchester Creek specimen; one of the bats yielded two males and six females while the other had two males and five females.

We take pleasure in naming this new form *B. calverti,* in honor of Dr. Philip P. Calvert, Professor Emeritus of Zoology at the University of Pennsylvania, who has been a patient teacher and honored friend to both of us.

We express our sincere thanks to C. C. Sanborn, Chicago Natural History Museum, and to P. H. Kritzsch, University of Kansas Museum of Natural History, for handling the identification of the original bat. We are also most grateful to Letitia W. Rawles for the excellent representations of the flies.

Basilia calverti n. sp.

Specimens examined: Holotype female and allotype male from *Myotis volans interior* Miller (the interior long-legged bat) collected some eight miles north of Divide, Colorado, on Manchester Creek at approximately 8,000 feet altitude on 1 September 1951, by R. M. Stabler. Four male and eleven female paratypes from *M. v. interior* collected three miles north of Colorado Springs at about 6,300 feet altitude, on 18 June 1952, by R. M. Stabler.

Disposition of types: Female holotype, male allotype, and seven female paratypes in the Carnegie Museum, Pittsburgh, Pa. A male and female paratype deposited in each of the following collections: the British Museum (Natural History), London; the Museum of Comparative Zoology, Harvard University; the Chicago Natural History Museum; and collection of G. F. Ferris, Stanford University, California. The three host bats from which the type series was collected are in the Carnegie Museum.

Female (fig. 1). Length exclusive of head, 2.2 mm. *Head* with the characteristics of the genus, the eyes two-faceted. *Thorax* on the ventral side with a median suture running the full length, beginning at a notch in the anterior prothoracic border and continuing as a straight line which broadens between the mesocoxae and immediately narrows again. On the dorsal side, tiny halteres are noted mesad of the metacoxae and arising from a suture which divides two sclerites, probably the metatergite and the dorsally rotated metapleuron. Otherwise there appears to be no striking diagnostic feature on the thorax on either the dorsal or the ventral side.

The *abdomen* is broad, oval. Dorsal side: Tergite *a* (terminology of Ferris, 1924) consists of three parts. The median part, which probably is the tergite proper, is more or less oblong, about the same width as the median thoracic tergite, and definitely less than half the length of tergite *b*. Its anterior margin, which lies under the median thoracic tergite, is narrower than the posterior one; the sides are irregularly shaped, with a slight notch forming two

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FIG. 1. *Basilia calverti* n. sp., female. Left, dorsal view; right, ventral view.

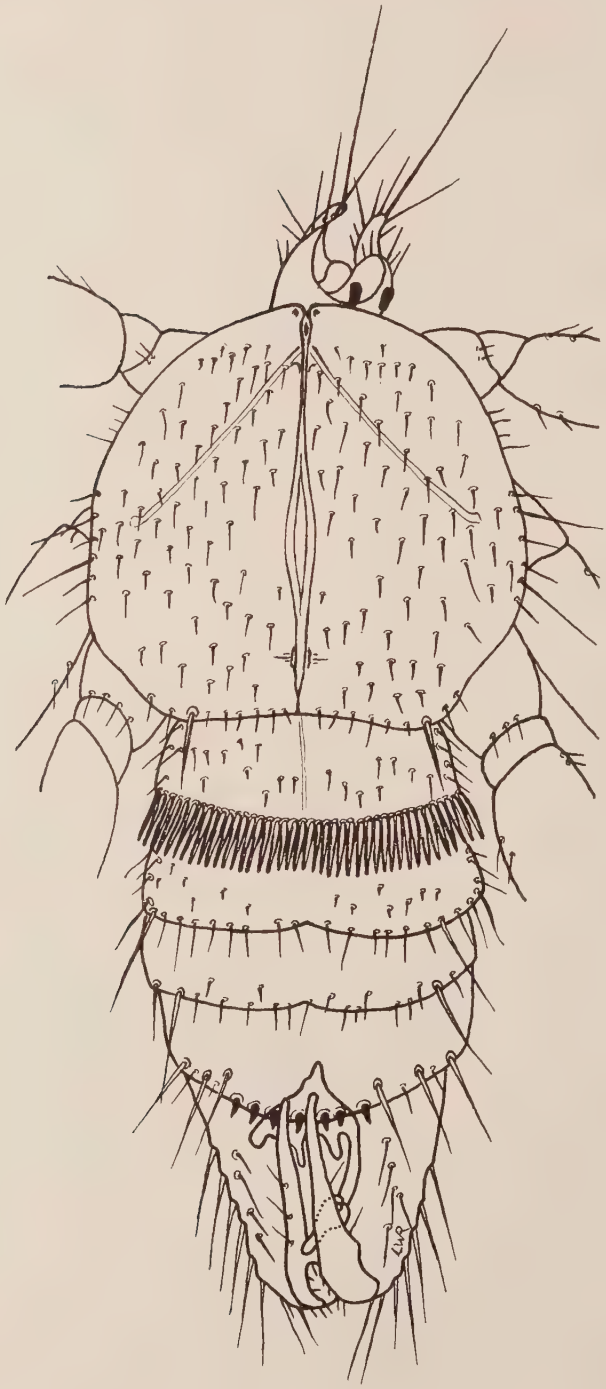

FIG. 2. *Basilia calverti* n. sp., male. Ventral view.

lateral lobes. Its posterior margin has a backward reaching apex on the midline and it is set with a row of prominent black setae. Lateral of the middle piece there is a pair of triangular plates, probably the pleurons, which are only lightly sclerotized and bear no setae. In life, tergite *a* slopes steeply upward, nearly perpendicular to the surface of the thorax and the rest of the abdomen, so that the large marginal setae are erect rather than flat on the body. Tergite *b* is not as wide as the abdomen, which here is wider than the thorax, and is only a little wider than tergite *a*, including the lateral pieces. Its length is three-fourths its width; it is widest anteriad and has its margins scalloped so that there are two lateral lobes and a posterior lobe on either side. The posterior margin and the postero-lateral margin, but not the antero-lateral margin, are set with setae longer than those on tergite *a*, and longest posteriorward. There are irregular patches of sparse, small setae over its surface. Tergite *c* consists of two small, rather oval, lobes narrowly connected at the median line, each with about five large setae on the posterior margin. In addition to some small setae arranged in patches on the membranous area, there is a row of large setae opposite the end of tergite *b*, and another opposite the end of tergite *c*. Tergite *d* consists of two flat, elongate, lobes broadly connected on the median line and bearing setae along the posterior margin which are a little smaller than those on the posterior margins of the other tergites. It is similar to that found in *B. forcipata* Ferris (1924) in that it is divided so as to present a forceps-like appearance, and very probably they do, indeed, articulate. It is observed that in cleared specimens, the medial margins of these lobes each bears a tooth-like projection, so that the space between them is keyhole shaped. This character is not so obvious in uncleared specimens and may or may not be present also in *B. forcipata*.

Ventral side: Basal sternite is 0.3 mm. long, less than one-half the length of the thorax and about one-fourth the length of the abdomen; laterally it reaches only as far as the proximal end of the metacoxae and is not as wide as the thorax; its posterior margin bears the usual ctenidium. The membranous abdomen posteriad of the basal sternite is thickly set with rows of small setae that become larger posteriorly. About 0.6 mm. behind the ctenidium is a pair of widely separated lightly sclerotized sternites, oval in shape, each bearing a median row of six small setae and a row of six large setae on the posterior margin. Just caudad of these sclerites is a short but wide lobate median sternite, with a row of about twelve small setae across it and a row of about sixteen large setae on the posterior margin. At the median line there is a more or less well marked tooth on both the posterior and the anterior margins; these are stronger in some specimens, weak or wanting in others. The terminal sternite is strongly sclerotized caudad, where it is clearly bilobed and beset with setae, but its anterior margin is difficult to distinguish as it merges with the membranous region, sometimes without a well-defined line. The under side of the forceps-like structure is sclerotized and perhaps should be called terminal, although it lies above the previously mentioned sternite.

Male (fig. 2). Length 2.0 mm. The "internal chitinous structures of doubtful holomogy" mentioned by Ferris when describing *B. forcipata* appear to be present in the posterior part of the abdomen. The basal sternite bears the ctenidium. The second and third sternites are concave at the midline; the fourth is strongly convex in outline. In other respects the male closely resembles Ferris' figure of *B. antrozoi* (1916).

DISCUSSION

Diagnosis. The American species of the genus *Basilia* were tabulated by Scott (1936), and only two species have been added since, one of which is North American. There are nine species now assigned to the North American fauna. Structural differences exhibited by *B. calverti*, as compared with these other species, are summarized below.

The prominent finger-like process on the mesonotum of *B. boardmani* Rozeboom (1934) sets that species off from all others. From *B. antrozoi* (Townsend, 1893), *B. calverti* is at once differentiated by the fact that the former appears to have the abdomen three-segmented; in the latter it is four-segmented. *B. ferrisi* Scott (1936) and *B. corynorhini* (Ferris, 1916) both have the basal sternite of the female so long that the ctenidium seems to be placed in the middle of the abdomen, while in *B. calverti* the basal sternite is quite short.

B. forcipata Ferris (1924) is certainly the nearest to the species under discussion. In the female, the posterior margin of tergite *a* is evenly rounded in *B. forci-*

pata, but bears a medial apex in *B. calverti;* furthermore, in *B. forcipata* this tergite seems to be all in one piece, rather than in three. In *B. forcipata,* tergite *b* is quite similar to that of *B. calverti,* but in the latter the margins are more strongly scalloped. On the ventral side the sclerotized plates of the two species are very decidedly different, the ctenidial-bearing sternite in *B. calverti* being markedly shorter, and there seems to be an additional sternite at the end of the abdomen lying beneath the forceps-like tergite *d,* not present in *B. forcipata.*

Host. As *B. calverti* is a wingless insect it must pass from host to host at times of the latter's close physical association, such as during copulation, roosting, or hibernation. Whereas not too much appears to be known of the life history of *M. volans interior,* it has been said not to be a social species to any degree, and in general to avoid caves (Miller and Allen, 1928). This would tend to suppress the spread of its parasites as well as the exchange of parasites with other species.

This *interior* race of *M. volans* is reported as ranging from eastern Washington and Oregon through California, Idaho, Montana, Wyoming, Colorado, New Mexico, Nevada, Utah, Arizona, Texas, and northern Mexico (Miller and Allen, 1928). The species is described as forest-loving, preferring high, open woods, ranging in the summer to at least 11,000 feet in the Sierra Nevadas (Allen, 1919). It was reported as taken at 11,400 feet in the Taos Mountains of New Mexico (Bailey, 1931), and Warren (1910) took it in Saguache Co., Colorado at 8,700 feet. The *interior* race is said to prefer the more arid regions of the species' range.

Parasite. The new species of *Basilia* described herein considerably extends the reported range of the genus in this hemisphere. Of the more than a dozen previously recorded species from the new world: six have been reported from Brazil only (*ferruginea, mirandoribieroi, plaumanni, silvae, speiseri,* and *travossosi*); one from Paraguay (*carteri*); two from Panama (*dunni* and *myotis*); one from Costa Rica (*ferrisi*); two from Mexico only (*mexicana* and *pizonychus*); one from Florida (*boardmani*); one (*forcipata*) from California, New Mexico, Louisiana, and Mexico; another (*antrozoi*) from California, Lower California, New Mexico, Louisiana, Texas, and Mexico; and one from California only (*corynorhini*). As the species from California and New Mexico do not appear to have come from further north than Los Angeles, *B. calverti* extends the northern range of the genus 375 odd miles. Its altitude, 6,000 to 8,000 feet, is markedly higher than that for any New World species thus far reported, while the host bat is known to occur regularly at even greater altitudes. The descriptions indicate that other American species have been collected in zones no higher than the Sonoran, with most of them being Tropical or Subtropical. *B. calverti,* on the other hand, was taken at the upper limits of the Transition zone, where it merges with the Canadian. It is interesting that its host, *M. volans interior,* is said by Miller and Allen (1928) to prefer the more arid, dry-country areas of the species range, going up into the high mountain forests only as a summer migrant.

SUMMARY

Both sexes of a new species of wingless, parasitic fly, *Basilia calverti,* family NYCTERIBIIDAE, are described from the interior long-legged bat (*Myotis volans interior*) taken at approximately 8,000 feet in the mountains some eight miles north of Divide, Colorado, and near Colorado Springs at 6,300 feet.

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COMPARATIVE DEVELOPMENT OF *PLASMODIUM RELICTUM* OOCYSTS IN *ANOPHELES QUADRIMACULATUS, A. ALBIMANUS,* AND *CULEX PIPIENS*[1, 2]

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The comparative susceptibility of four anophelines to an avian malarial parasite, *Plasmodium relictum,* was reported by Hunninen (1951). The sporozoites from these mosquitoes, dissected between the twelfth and twentieth days, were shown to be infective when injected into birds.

The present report deals with the percentage development of *P. relictum* in two anopheline species, the intensity of infection in these mosquitoes, and the rate of growth and the earliest appearance of sporozoites in the salivary glands of *Anopheles quadrimaculatus, A. albimanus,* and in the control *Culex pipiens* dissected between the sixth and thirteenth days after feeding on infected birds.

METHODS

English sparrows caught at Columbia, S. C., served as the source of *P. relictum* which then was passed to other English sparrows by blood inoculation. The Q-1 strain of *A. quadrimaculatus,* which has been maintained and used for several years by investigators at the Columbia laboratory, was used in these experiments. The *A. albimanus* strain used came originally from Panama and is designated as A-2.

Both, the anopheline species and the control, *Culex pipiens,* fed on infected birds simultaneously. These mosquitoes were then kept in an insectary ($78° \pm 2°$) until dissected.

Measurements of the oocysts were made after a sufficient amount of saline was added to prevent pressure on the gut by the cover glass.

RESULTS

Percentage of mosquitoes infected.

The percentages of *C. pipiens, A. albimanus,* and *A. quadrimaculatus* that became infected were 80%, 80%, and 73%, respectively. In an earlier study by Hunninen (1951), using these same species of mosquitoes infected with *P. relictum,* the respective percentages were: 87, 80, and 35.

Intensity of infections.

Although a larger number of *A. albimanus* than *A. quadrimaculatus* became infected, larger numbers of oocysts developed in the latter. The average numbers of oocysts were 236, 207, and 79 in *Culex pipiens, A. quadrimaculatus,* and *A. albimanus,* respectively. In a study previously published by the author, the same order

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[2] This work was carried out in the Laboratory of Tropical Diseases, U. S. Public Health Service, Columbia, South Carolina. I am indebted to Dr. Martin D. Young and Dr. Robert Burgess for their aid.
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of intensity of infection was shown in these three species of mosquitoes. One possible explanation for the smaller number of oocysts in *A. albimanus* is its smaller blood meal compared with that of *A. quadrimaculatus* which is a larger mosquito and engorges more fully, thus taking in larger quantities of blood per meal.

Eyles and Young (1950) found *A. quadrimaculatus* (Q-1) to be more susceptible to a South Carolina strain of *P. falciparum* than was *A. albimanus* (A-2) and showed that this was not due to variation in the production of ookinetes since equal numbers of ookinetes were found in the intestines of both species of mosquitoes; therefore, the difference in susceptibility must have operated after fertilization.

Table 1 shows a numerical breakdown of oocysts into groups. This shows that 51.5 per cent of *C. pipiens* and 43 per cent of *A. quadrimaculatus* became infected with more than 100 oocysts per midgut, and 30 per cent of *A. albimanus* showed numbers above 100. Several of the *Culex pipiens* and *A. quadrimaculatus* were very heavily infected, having over 500 oocysts per midgut, while none of the *A. albimanus* had such large numbers; only 8 out of 101 *A. albimanus* harbored more than 200 per midgut.

TABLE 1.—*Comparison of the number of oocysts of* Plasmodium relictum *in a culicine and two anopheline species of mosquitoes*

		Number of oocysts				
		1 to 9	10 to 24	25 to 99	100 to 499	over 500
Culex pipiens	Number with oocysts	0	2	14	9	8
	Per cent	0	6.1	42.4	27.3	24.2
Anopheles quadrimaculatus	Number with oocysts	14	9	15	20	9
	Per cent	21	13	23	30	13
Anopheles albimanus	Number with oocysts	22	9	40	30	0
	Per cent	21.5	8.5	40	30	0

Growth of the oocysts.

There was no correlation between the numbers of oocysts and their sizes. In the sixth, seventh, and eighth days of development in *Culex pipiens*, the coefficients of correlation were 0.19, minus 0.39, and minus 0.28, respectively. This was also true for the two anopheline species.

Table 2 shows a summary of the growth of the oocysts in the three species of mosquitoes over a period of days. The average sizes are those of five series of experiments.

This development is shown graphically in Figure 1. On a given day the average sizes of the oocysts in the control were larger than those in the anophelines. On the sixth, seventh, and eighth days the oocyst sizes in *A. quadrimaculatus* were slightly smaller than in the control but definitely larger than in the *A. albimanus*. No explanation is available for the marked decrease in sizes in *A. quadrimaculatus* during the ninth and eleventh days. *A. albimanus* fed simultaneously on the same infected birds, yet no such decrease in oocyst size occurred in this mosquito. The growth of the oocysts in *A. albimanus* was slow but reached almost the same average sizes on the twelfth and thirteenth days as those in *A. quadrimaculatus* on the eighth day.

The development of the oocysts to maturity and the appearance of sporozoites in the salivary glands occurred more rapidly in *A. quadrimaculatus* than in *A. albi-*

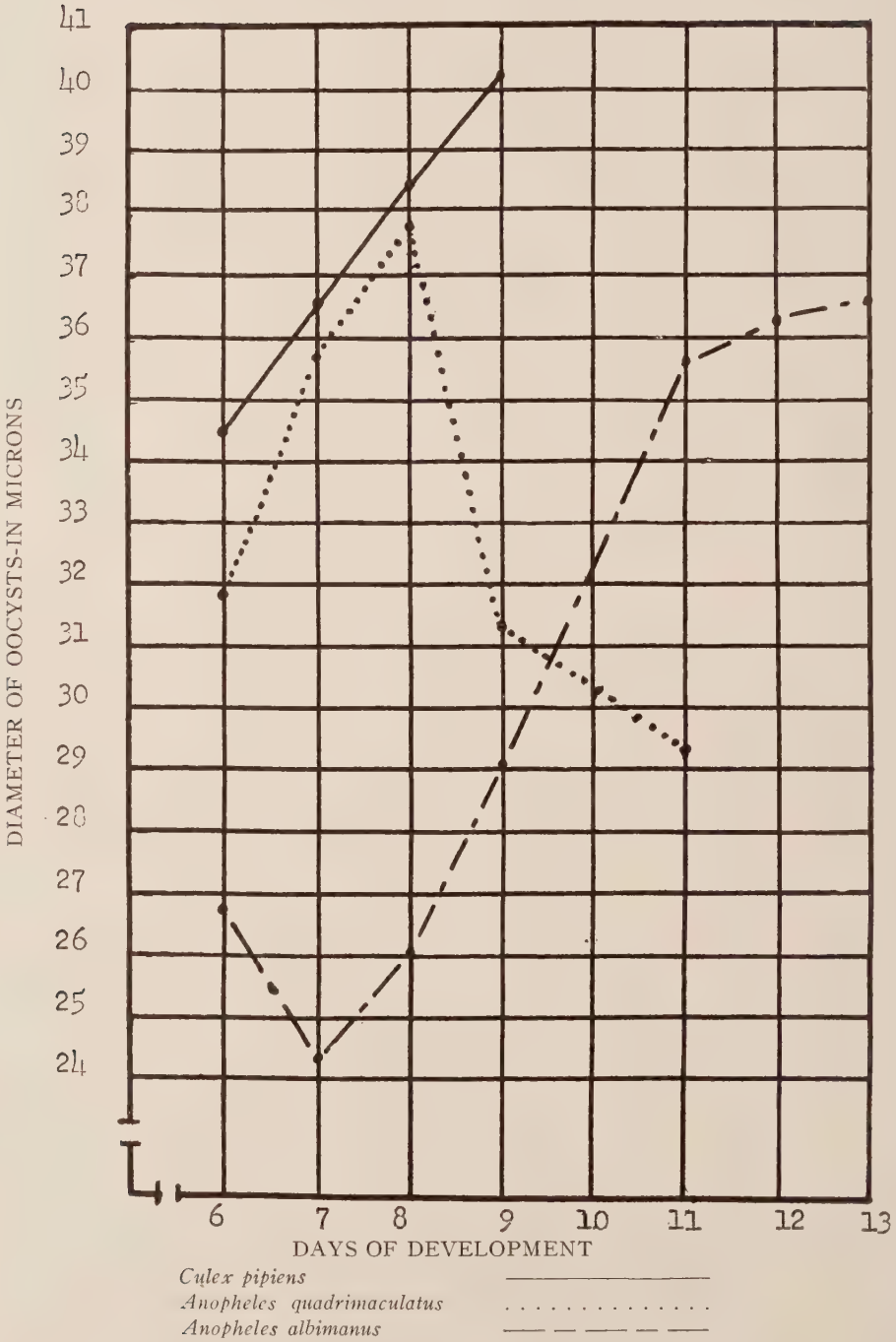

FIG. 1. Comparison of the growth of oocysts of *Plasmodium relictum* in a control culicine and in two anophelene mosquitoes.

manus. Table 3 shows that in two out of ten *A. quadrimaculatus* a few sporozoites were found as early as the sixth day after feeding; on the following days, up to the thirteenth day, one-half of these mosquitoes showed sporozoites. The first appear-

TABLE 2.—*Sizes of oocysts of* Plasmodium relictum *in* Anopheles quadrimaculatus, Anopheles albimanus, *and control* Culex pipiens, *between the sixth and thirteenth days of development*

	Days after feeding	Number of mosquitoes dissected	Average number of oocysts per gut	Number of oocysts measured	Range in oocyst sizes (microns)	Average sizes of oocysts	Median
Culex pipiens	6	4	273	73	19.2–43.2	34.54 ± 0.75	35.2
A. quadrimaculatus	6	8	277	123	4.0–49.6	31.94 ± 0.706	32.0
A. albimanus	6	3	74	52	6.4–36.8	26.86 ± 0.653	27.2
Culex pipiens	7	7	241	130	14.0–52.8	36.65 ± 0.507	36.8
A. quadrimaculatus	7	6	283	106	16.0–49.6	35.81 ± 0.673	35.2
A. albimanus	7	9	79	177	16.0–35.2	24.42 ± 0.286	24.0
Culex pipiens	8	7	377	120	11.2–48.0	38.48 ± 0.657	40.0
A. quadrimaculatus	8	9	30	120	22.4–51.2	37.85 ± 0.554	38.4
A. albimanus	8	11	89	254	19.2–40.0	26.02 ± 0.77	25.6
Culex pipiens	9	7	70	85	17.6–56.0	40.25 ± 0.845	40.0
A. quadrimaculatus	9	10	216	142	14.1–48.0	31.44 ± 0.607	32.0
A. albimanus	9	10	29	104	16.0–44.8	29.12 ± 0.51	28.8
A. quadrimaculatus	11	7	222	168	12.8–48.0	29.44 ± 0.647	28.8
A. albimanus	11	18	112	310	19.2–48.0	35.71 ± 0.281	36.0
A. albimanus	12	10	49	144	24.0–51.2	36.66 ± 0.445	36.8
A. albimanus	13	3	97	44	28.8–48.0	36.79 ± 0.722	36.8

ance of sporozoites in the salivary glands of *A. albimanus* was on the ninth day after feeding and on the eleventh, twelfth, and thirteenth days more than one-half (34 out of 52) showed sporozoites. In the *Culex* controls, sporozoites appeared on the sixth day; on the eighth and subsequent days all of these mosquitoes showed sporozoites in the glands. It is of interest to note the number of sporozoites in the controls and in the anophelines. In *Culex*, on the eighth and following days, all showed 4-plus infections but in the anophelines only six per cent showed 4-plus infections in the salivary glands. All of the mosquitoes in Table 3 had oocysts on their stomachs.

DISCUSSION

The early malariologists held the belief that avian malaria was transmitted by the culicine and the human malaria by the anopheline mosquitoes. It has been shown, however, that some avian malarias can develop in the anophelines. One avian malarial parasite, *P. relictum*, as shown by Hunninen (1950 and 1951), develops readily and completely in certain of the anophelines, if it is reared in its natural hosts (especially the English sparrow) rather than in the canary.

TABLE 3.—*Appearance of sporozoites of* Plasmodium relictum *in the salivary glands of a culicine and two anopheline mosquitoes between the sixth and thirteenth days of development*

Mosquito species	Days after feeding	Negative	Sporozoite intensity			
			1+	2+	3+	4+
Culex pipiens	6	2		1		1
A. quadrimaculatus	6	8	2			
A. albimanus	6	5				
Culex pipiens	7	6		2		2
A. quadrimaculatus	7	1	1	1		
A. albimanus	7	9				
Culex pipiens	8	0				8
A. quadrimaculatus	8	8	4	2	1	1
A. albimanus	8	11				
Culex pipiens	9	0			1	10
A. quadrimaculatus	9	6	1	4		
A. albimanus	9	1	1			
Culex pipiens	11	0				3
A. quadrimaculatus	11	4	2		1	
A. albimanus	11	8	2	5	3	
Culex pipiens	12	0				4
A. quadrimaculatus	12	3	1	3	2	
A. albimanus	12	5	1	5	3	2
Culex pipiens	13	0				5
A. quadrimaculatus	13	9	5	3		
A. albimanus	13	4		7	5	1

* 1+ = 1 to 9 sporozoites.
2+ = 10 to 99 sporozoites.
3+ = 100 to 999 sporozoites.
4+ = over 1000 sporozoites.

Using *Culex pipiens* as a control, the data of the present paper compare the development of an avian malarial parasite, *P. relictum* (between the sixth and thirteenth days), in *A. quadrimaculatus* (Q-1)and *A. albimanus* (A-2) and in the control *Culex pipiens.*

The average oocyst sizes in *A. quadrimaculatus* on the sixth, seventh, and eighth days were found to be only slightly smaller than in the control *Culex.* The slowest growth took place in *A. albimanus,* but by the twelfth and thirteenth days the sizes almost compared with those in *A. quadrimaculatus* on the eighth day of development. The oocysts in *A. albimanus* were more uniform in size compared with those in *A. quadrimaculatus* and *C. pipiens,* that is, there were not many very small or very large ones on any day of development.

Eyles and Young (1950), using the Q-1 and A-2 strains of anophelines (which were used in the present work), infected with the South Carolina strain of *P. falciparum,* also found smaller oocysts and a slower rate of development to maturity in *A. albimanus* than in *A. quadrimaculatus.*

SUMMARY

A study has been made of the percentage of mosquitoes infected, the intensity of infection, and the rate of growth and development to maturity of an avian malarial parasite, *Plasmodium relictum,* in *Anopheles quadrimaculatus, A. albimanus,* and the control *Culex pipiens.*

As far as the number of mosquitoes that became infected is concerned, *A. albimanus* proved to be as susceptible as the control *Culex;* 80 per cent became infected in each species. *A. quadrimaculatus* was slightly less susceptible.

A study of the intensity of infection shows that the average number of oocysts was consistently smaller in *A. albimanus,* while in *A. quadrimaculatus* it was only slightly less than in the control *Culex.* Of the *A. quadrimaculatus* and the control *C. pipiens,* 43.0 and 51.2 per cent respectively, harbored over 100 oocysts per stomach and in several over 1000 were found. None of the *A. albimanus* had over 500 oocysts.

The slowest growth of oocysts occurred in *A. albimanus.* The rate in *A. quadrimaculatus* was only slightly less than that in the control *C. pipiens.*

Development of the oocysts to maturity was also slowest in *A. albimanus.* The earliest appearance of sporozoites in the salivary glands of *A. albimanus* was on the ninth day after feeding. A few *A. quadrimaculatus* showed sporozoites as early as the sixth day. About one-half of the infected controls harbored sporozoites on the sixth and seventh days and all had 4-plus glands on subsequent days.

Four-plus glands were found in a few of the anophelines but usually the number was less than that in *C. pipiens.*

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THE DISTRIBUTION OF SOIL ACTINOMYCETES ANTAGONISTIC TO PROTOZOA

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The antibiotic approach to the problem of chemotherapy for protozoan diseases is suggested by the successful treatment of bacterial infections with such substances as penicillin, streptomycin, aureomycin, chloromycetin and terramycin. The general ineffectiveness of these antibacterial agents in treating protozoan diseases (Armstrong *et al.,* 1950; Felsenfeld *et al.,* 1950; Hughes, 1950; Ishihara and Felsenfeld, 1949; Loefer, 1950; Most, 1949; Wyatt and Vandegrift, 1950) recommends the direct use of protozoa as test organisms in a search for antibiotics active against these forms. This is in contrast to the usual procedure wherein antibacterial agents have been isolated and subsequently tested for a coincidental ability to inhibit protozoa. This indirect approach is understandable in view of the difficulties in cultivating parasitic protozoa and the paucity of such species that can be grown in pure culture.

Numerous reports in the literature (Balamuth and Brent, 1949, 1950; Hogue, 1928; McCowen *et al.,* 1951; Schatz *et al.,* 1946; Taliaferro *et al.,* 1944; Waksman *et al.,* 1949) on the inhibition of protozoa *in vitro* by various microorganisms and their products indicate a widespread distribution of antiprotozoan substances of microbial origin. For the present investigation actinomycetes were tested for antiprotozoan activity, because these organisms produce most of the more effective antibiotics in use today.

METHODS AND MATERIALS

The protozoa *Herpetomonas culicidarum, Euglena gracilis,* and *Tetrahymena geleii* were employed as test organisms. These species were selected because they were readily available and easily grown in pure culture. Of the two flagellates, *H. culicidarum* is related to important parasites of man and domestic animals. The ciliate *T. geleii* represents a group phylogenetically different from the flagellates.

These protozoa were grown on the following distilled water media. For *E. gracilis:* KH_2PO_4 0.05%, NH_4NO_3 0.05%, $MgSO_4 \cdot 7H_2O$ 0.02%, $FeSO_4 \cdot 7H_2O$ 0.001%, $CaCl_2 \cdot 2H_2O$ 0.001%, B.B.L. N–Z-Case 0.2%, $CH_3COONa \cdot 3H_2O$ 0.1%; pH 7.0. For *T. geleii:* KH_2PO_4 0.05%, Bacto tryptone 0.5%, Bacto peptone 0.5%, Bacto yeast extract 0.05%; pH 7.0. For *H. culicidarum:* glycerol 0.5%, Bacto tryptone 0.4%, N.B.C. Liver L (1 : 20) 0.1%, Na_3 citrate $\cdot 2H_2O$ 0.04%, hemin 2.0 mg.%; pH 8.0. Hemin was dispensed from a stock solution prepared by dissolving 50.0 mg. $Na_2S_2O_4 \cdot 2H_2O$ in 50.0 ml. 0.2 N NaOH; this was heated to 46° C, and then 25.0 mg. hemin were added to give a clear solution.

Actinomycetes were obtained by picking colonies from glucose-asparagine agar platings of forest, field, garden, and greenhouse soils and cow, horse, and rabbit dung. From about 300 original isolates, 82 cultures differing in pigmentation and

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manner of growth on agar media were selected for further study and maintained on dextrose-peptone agar slants.

Actinomycetes were grown on the classical nutrient broth, glucose-asparagine, and glucose-peptone substrates (Waksman, 1932), as well as N–Z-Case-succinate medium containing KH_2PO_4 0.1%, $MgSO_4 \cdot 7H_2O$ 0.01%, $FeSO_4 \cdot 7H_2O$ 0.001%, $CaCl_2 \cdot 2H_2O$ 0.001%, B.B.L. N–Z-Case 0.1%, succinic acid 0.2%. These media were prepared with distilled water, adjusted to pH 7.0 and solidified with 1.5% agar for plates and slants or employed as semi-solid broth with 0.1% agar to support surface pellicle growth. All cultures were incubated at 25° to 28° C in the light.

Every actinomycete was tested on semi-solid nutrient, glucose-asparagine, and N–Z-Case-succinate broth against each of the three protozoa. For this preliminary screening, 2.0 ml. portions of the medium in 50.0 ml. test tubes were inoculated and incubated for 5 to 7 days by which time satisfactory surface pellicles usually had

TABLE 1.—*Inhibition of protozoa by actinomycetes*

Inhibition of	Active tests with medium			Antagonistic cultures	
	Nutrient	Glucose asparagine	N–Z-Case	Total	%
One protozoan only :					
E. gracilis	9	8	8	14	17.1
H. culicidarum	1	4	4	6	7.5
T. geleii	0	1	0	1	1.2
Two protozoa :					
E. gracilis and T. geleii	0	0	0	0	0
E. gracilis and H. culicidarum	1	1	2	3	3.7
H. culicidarum and T. geleii	2	1	1	2	2.4
All three protozoa : *E. gracilis H. culicidarum and T. geleii*	1	1	1	1	1.2
Total	14	16	16	27	33.1
		46			

developed. Then 18.0 ml. of protozoan cultures, very lightly inoculated immediately beforehand, were aseptically added to the tubes. Final observations were made after 7 to 9 additional days, at which time the actinomyces-free controls exhibited good growth of protozoa.

Actinomycetes which inhibited growth of one or more of the protozoa were regrown in 20.0 ml. of the most suitable medium dispensed in 125 ml. Erlenmeyer flasks. After 7 days' incubation, samples of the culture fluids were carefully decanted into sterile tubes with a minimal carry-over of mycelial fragments and heated at 80° C for 10 minutes to kill actinomyces spores. Heated and unheated dilutions of these broths were then tested by the tube technic described in the preceding paragraph.

Antagonism toward bacteria was determined by streaking each actinomycete diametrically across a nutrient agar plate. After 3 days' incubation suspensions of the test bacteria were cross streaked and zones of inhibition were observed after 24–48 hours additional incubation.

EXPERIMENTAL RESULTS

In the preliminary screening, 46 or 6.2% of the original 738 tests (82 actinomycetes on 3 media against 3 protozoa) exhibited activity against one or more of the

protozoa. (Table 1.) Of the 82 actinomycetes, 27 or 33.1% were inhibitive. *T. geleii, H. culicidarum,* and *E. gracilis,* in this order, were increasingly sensitive to the actinomycetes (Table 2). However, the test procedure for *T. geleii* may not

TABLE 2.—*Relative sensitivity of protozoa to actinomycetes*

Inhibition of	Active tests with medium			Total active filtrates
	Nutrient	Glucose-asparagine	N–Z-Case	
E. gracilis	11	10	11	32
H. culicidarum	5	7	8	20
T. geleii	3	3	2	8

have been as suitable as for the flagellates since the actinomycete growth in many tubes disappeared due to ingestion by the ciliated phagotroph. In contrast to this, the actinomyces mycelium persisted following inoculation with *E. gracilis* and *H. culicidarum.*

In view of the closer phylogenetic relationship of the euglenoid to the herpetomonad *vis-a-vis* the ciliate, it was assumed that the sensitivity of these two organisms would be of the same order of magnitude and differ from that of *T. geleii.* But the data in Tables 1 and 2 suggest no close relationship, on the basis of sensitivity to actinomycetes, between the flagellates as compared with the ciliate.

Variation in the composition of the three actinomyces media was without much effect on the production of antiprotozoan activity. (Tables 1 and 2.) While the glucose-asparagine broth is a relatively simple and defined substrate, the N–Z-Case and nutrient broths both are complex.

Of the 246 actinomycete culture filtrates tested against *E. gracilis,* not a single one caused bleaching of this organism. The 82 actinomycetes studied included several strains that were characteristically similar to *Streptomyces griseus* which produces streptomycin, an agent known to cause loss of chlorophyll (Provasoli *et al.,* 1948; Lwoff *et al.,* 1949).

The activity of inhibitive actinomycetes was confirmed in repeated experiments where dilutions of the culture broths were tested for quantitative comparison. On the basis of these studies, the five most active cultures were found to produce thermostable agents effective only against the flagellates. One culture broth also inhibited *T. geleii,* but only when unheated. (Table 3.) In the dilutions tested, an effect

TABLE 3.—*Inhibition of protozoa by heat-stable products of actinomycetes*[1]

Actinomycetes no.	Protozoa	pH of heated broth	Inhibitive dilution of heated broth	
			Glucose-asparagine	N–Z-Case
9	*E. gracilis*	6.43	> 1 : 33	
32	*E. gracilis*	9.29		> 1 : 5 < 1 : 10
84	*E. gracilis*	4.16	> 1 : 10 < 1 : 33	
41[2]	*H. culicidarum*	9.03		> 1 : 33 < 1 : 100
64	*H. culicidarum*	6.09	> 1 : 100	
		9.25		> 1 : 10 < 1 : 33

[1] Unheated culture broths tested at 1 : 10 were all active.
[2] Unheated culture broth also active against *T. geleii.*

of unfavorable pH was ruled out. This indicated the presence of a thermolabile agent active against the ciliate in addition to one or more heat-stable substances responsible for the inhibition of *H. culicidarum.* These results are in accord with the already mentioned greater sensitivity of the flagellates to the actinomycetes.

Actinomycetes Nos. 41, 64, and 84, which are listed in Table 3, appeared to be

strains of *Streptomyces griseus*. The streptomycin-producing strain of this organism has been reported to elaborate streptocin, an antibiotic active against *Trichomonas vaginalis* and certain bacteria (Waksman *et al.*, 1949). It is unlikely that actinomycetes Nos. 41, 64, and 84 produce streptocin since these cultures were completely inactive antibacterially by the streak test. The results of such tests with twenty antiprotozoan actinomycetes revealed that only 11 inhibited one or more of four test bacteria: *Bacillus subtilis, Escherichia coli, Serratia marcescens,* and *Staphylococcus aureus.*

SUMMARY AND CONCLUSIONS

For many serious protozoan infections of man satisfactory means of chemotherapy is lacking. The present study explored the antibiotic approach to this problem. The test organisms were *E. gracilis, H. culicidarum,* and *T. geleii* which grow readily in pure culture. Since most of the antibiotics efficacious in treating bacterial infections are products of actinomycetes, this group was investigated, in preference to bacteria and molds, for the ability to synthesize antiprotozoan agents.

The present study indicated that in only 46 out of a total of 738 tests did inhibition of protozoan growth occur. Of the 82 actinomycetes, 27 or 33 per cent were active. The two flagellated protozoa were far more sensitive than the ciliate.

At least five of the 82 actinomycetes elaborated heat-stable antiprotozoan agents, one of which was inhibitive to *H. culicidarum* at a dilution greater than 1 : 100.

The fact that only 11 out of 20 antiprotozoan actinomycetes inhibited one or more of four test bacteria by the usual streak technic on nutrient agar emphasizes the unsuitability of bacteria as test organisms for the isolation of antibiotics inhibitive to protozoa.

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THE EARLY DEVELOPMENT OF THE DAUGHTER SPOROCYSTS OF THE STRIGEOIDEA (TREMATODA)*

ANNE VAN DER WOUDE, W. W. CORT, AND D. J. AMEEL

INTRODUCTION

Cort and Olivier (1941) described germinal masses, which serve as centers of multiplication of germinal cells, in the mother and daughter sporocysts of strigeoids. They postulated that in the early development of the germinal sacs in this group there is first a limited multiplication of the cells of the germinal line; then these cells develop directly into germinal masses, which consist of groups of embryos and germinal cells. The germinal masses are discrete entities, each surrounded by a thin membrane, and have a characteristic shape and size. They float freely in the body cavity of the sporocysts. Early stages of mother sporocysts and the daughters that are about to escape from the mother contain only germinal masses. The number of germinal masses in the sporocysts of a single species varies greatly and there appear to be differences between species. However, there are rarely fewer than 12 or more than 30 in each sporocyst. The largest embryos of the germinal masses are at the ends and the production of free embryos in both mother and daughter sporocysts appears to be accomplished only by their breaking off. They are replaced by the growth of other embryos which in their turn separate from the masses; new embryos appear to be constantly formed from the germinal cells which persist in the germinal masses and multiply throughout the reproductive life of the germinal sacs. This mechanism for the multiplication of germinal cells in the strigeoid group produces in the mother sporocyst a sufficient number of daughters to fill completely the digestive gland of the snail host, and in the daughters the enormous numbers of cercariae which escape during the life of an infection. Up to the present, germinal masses have been observed in nine different species of the superfamily STRIGEOIDEA indicating that this type of germinal development is characteristic for the whole group.

During the summers of 1949 and 1950 we undertook studies on the germinal development of the strigeoids at the University of Michigan Biological Station to obtain further details on the structure and development of the germinal masses. In a recent paper (Cort, Ameel, and Van der Woude, 1951) new data have been added on the development of the germinal masses in mother sporocysts. In the present paper we present further details on the structure of the germinal masses and on their development in daughter sporocysts.

MATERIALS AND METHODS

Observations were made on the structure and development of the germinal masses of *Diplostomum flexicaudum* (Cort and Brooks, 1928) in natural infections in *Stagnicola emarginata angulata* (Sowerby) and in experimental infections in *S.*

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palustris elodes (Say). Material was also available for similar observations on natural infections of *Cercaria modicella* (Cort and Brooks, 1928) from *Fossaria abrussa* (Say). Early stages of the development of the germinal masses in very immature daughter sporocysts were also observed in several infections of other strigeoid species that were too immature for precise identification. Most of the observations were made on living material. Early stages of the daughter sporocysts were removed from mothers for examination. Later stages were isolated from the digestive gland of the snail host. Neutral red was frequently used in *intra vitam* staining because it differentiates the germinal cells more clearly. Sections were made of mother sporocysts of *Diplostomum flexicaudum* containing germinal masses and daughters embryos. Sections 7 μ in thickness stained with iron hematoxylin gave the best results.

DATA FROM OBSERVATIONS

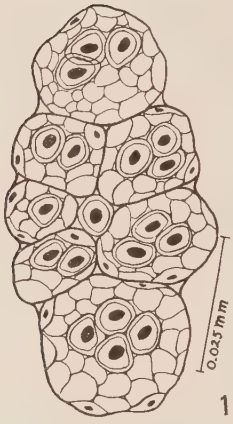
Structure of germinal masses in mother sporocysts

Typical germinal cells about 8 to 10 μ in diameter with large nuclei and nucleoli are present in small numbers near the middle of the germinal masses of strigeoid mother sporocysts (Figs. 1 and 2). Some of these germinal cells have been found whenever germinal masses have been carefully examined, except in a few cases in very old mother sporocysts. The remainder of the germinal mass is made up of very young daughter sporocyst embryos, the largest of which are at the ends. In these embryos it was possible both in living material and in sections to distinguish the germinal from the somatic cells. Thus in the germinal masses shown in figures 1 and 2 the embryos contained from one to five germinal cells. The largest embryos that formed the end components of the germinal masses in the mother sporocysts of *D. flexicaudum* and *C. modicella* were from 0.025 to 0.040 mm. in diameter and contained from 4 to 8 germinal cells. The body cavity and wall of these embryo daughter sporocysts were not yet clearly defined.

Development of daughter sporocyst embryos

The smallest free daughter sporocyst embryos in the mother sporocysts were from 0.03 to 0.04 mm. in diameter and contained from 6 to 8 germinal cells (Fig. 4). They had exactly the same structure as the largest end components of the germinal masses. Figures 5 and 6 illustrate slightly larger embryos with an increased number of germinal cells. Figure 7 is a section of a very young embryo which shows clearly the differences in structure between the germinal and somatic cells. Embryos at about this stage begin to elongate and the wall and body cavity become more clearly defined (Fig. 6). This stage was also illustrated by an embryo 0.038 by 0.027 mm. in diameter in a mother sporocyst of *C. modicella,* which contained 12 germinal cells. Another slightly older daughter sporocyst embryo of the same species, 0.073 by 0.045 mm. in diameter, had a thick wall and a well-defined body cavity, which contained 13 germinal elements. Three of these were single cells, and the others were composed of two, three, and four cells. Figures 8 to 11 show later stages in the development of daughter sporocyst embryos in which the germinal elements are in groups of two to five cells. Figure 12 shows the appearance of the germinal elements at this stage in sections. It was not possible to determine with certainty exactly how long germinal cells persisted in developing daughter sporocyst

PLATE I



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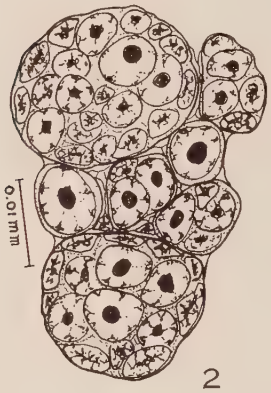

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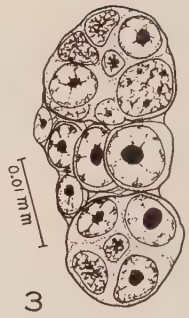

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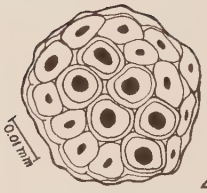

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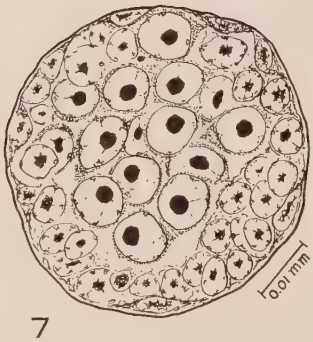

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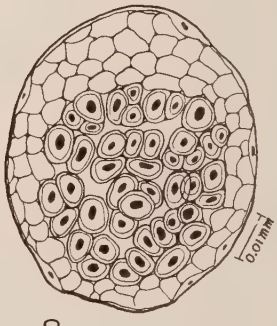

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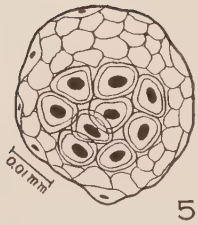

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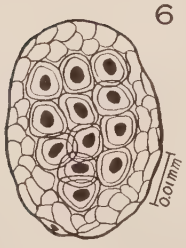

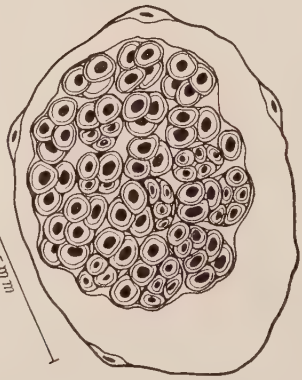

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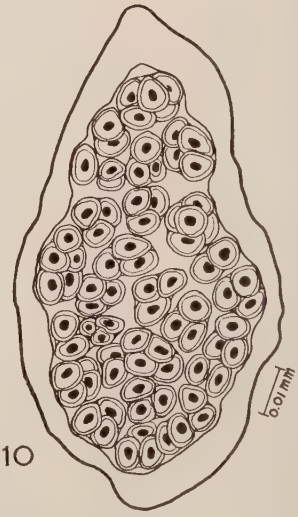

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embryos before all had developed into multicellular elements. However, in some embryos less than 0.1 mm. in length no separate germinal cells could be found. While most of our observations on the early development of daughter sporocysts were made on *D. flexicaudum* and *C. modicella,* we found similar stages in the mother sporocysts in several infections that were too immature for exact specific identification. One of these, however, was tentatively identified as *C. emarginatae* Cort, 1917.

In somewhat later stages of development, the daughter sporocyst embryos were more elongate and the difference between their anterior and posterior ends was more clearly defined. The largest of their germinal elements looked like typical germinal masses (Fig. 13). Although at this stage no single germinal cells were ever seen in daughter sporocysts, there was a considerable variation in the size of the germinal elements, the smallest of which consisted of only 3 to 5 components.

Later stages of daughter sporocysts that had not yet escaped from the mother are shown in figures 14 and 15. Their largest germinal masses appeared to be fully developed with their end components almost ready to break off. Figure 3 is a drawing of a section of a germinal mass from a daughter sporocyst of *D. flexicaudum* that had not yet escaped from the mother. In it can be seen both germinal cells and small embryos containing germinal cells. In general the germinal masses of the daughter sporocysts appear to be slightly smaller and more compact than those of the mothers.

Figure 16 is a drawing of a free daughter sporocyst of *C. modicella* which must have just escaped from the mother since no cercarial embryos had as yet broken off from its germinal masses. Usually even in the smallest free daughter sporocysts there were a few free embryos. Daughter sporocysts which contain only germinal masses are very characteristic. They have been studied in several strigeoid species besides *D. flexicaudum* and *C. modicella.* They always showed a considerable variation in the size and degree of development of their germinal masses, the smallest having usually only four or five components. For any species there was also a considerable variation in the number of germinal masses. Figures 14, 15, and 16 were made from sporocysts which contained small numbers of germinal masses because when larger numbers were present it was almost impossible to work out the details of structure.

Variations in germinal masses in immature daughter sporocysts

In order to get some idea of the variation in the numbers of germinal masses in daughter sporocysts in the same species we made a considerable series of counts

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DESCRIPTION OF FIGURES

PLATE I. Germinal masses and very early stages in the development of the embryos of strigeoid daughter sporocysts.

FIG. 1. Germinal mass, 0.079 by 0.044 mm., from mother sporocyst of *Cercaria modicella.*

FIG. 2. Section of a germinal mass from mother sporocyst of *Diplostomum flexicaudum.*

FIG. 3. Section of a germinal mass from a daughter sporocyst of *D. flexicaudum.*

FIG. 4. Very young embryo daughter sporocyst of *D. flexicaudum,* 0.03 by 0.03 mm.

FIGS. 5 and 6. Very young embryos of daughter sporocysts of *C. modicella,* 0.038 by 0.034 mm. and 0.041 by 0.030 mm. respectively.

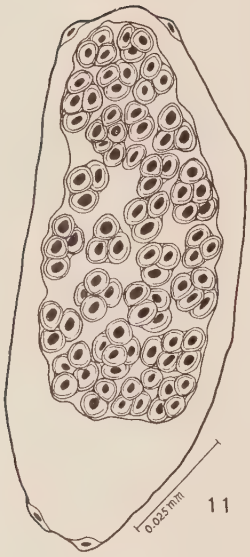
FIG. 7. Section of very young embryo daughter sporocyst of *D. flexicaudum.*

FIG. 8. Young embryo daughter sporocyst of strigeoid from *Fossaria abrussa,* 0.055 by 0.045 mm.; very probably *C. modicella.*

FIG. 9. Young embryo daughter sporocyst of *D. flexicaudum,* 0.058 by 0.050 mm.

FIG. 10. Young embryo daughter sporocyst of *C. modicella,* 0.093 by 0.048 mm.

PLATE II



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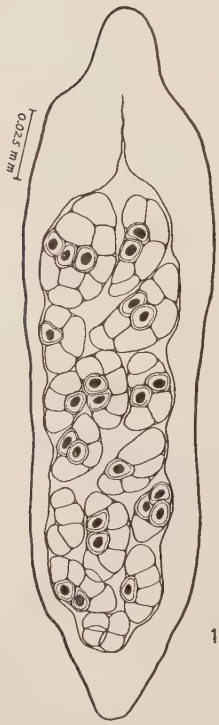

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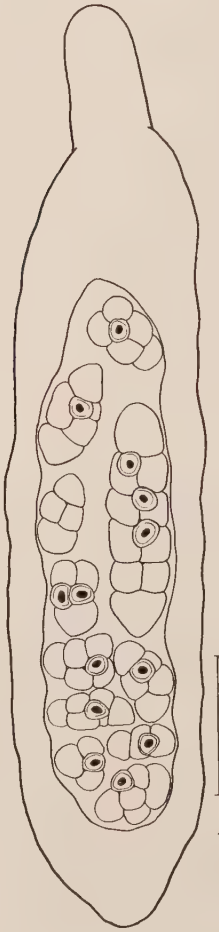

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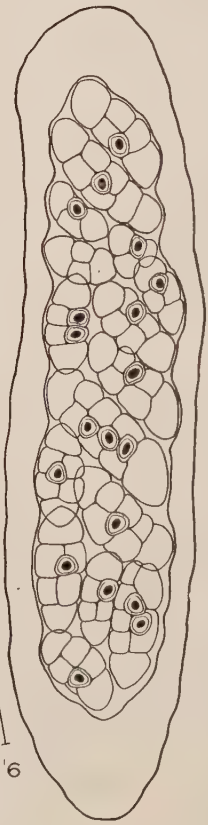

16

for *D. flexicaudum;* counts from 63 daughter sporocysts in various stages of development varied from 11 to 35 with an average of 20; thirty-nine were between 18 and 20. Considerable variation in the number of germinal masses in daughter sporocysts was also found in *C. modicella* and in several other strigeoid species. We also obtained some evidence of specific differences in the average number of germinal masses in daughter sporocysts. For example, 26 counts of the germinal masses in daughter sporocysts of *C. emarginatae* ranged from 13 to 20 with an average of 15. There are also specific differences in the size, shape, and in the number of components of the germinal masses of different species. However, the variations within a single species are so great in all these respects that much more data will be needed before any definite statements can be made.

As already noted, the germinal masses also showed a considerable variation in size and number of components in individual immature daughter sporocysts. In daughters that appeared about ready to escape from the mother, the largest germinal masses were fully developed while the smallest were very much smaller and had only four or five components. For example, the daughter sporocyst of *D. flexicaudum* shown in figure 15 contained 11 germinal masses which varied in size from one, 0.018 by 0.012 mm., with only four components to the largest, 0.060 by 0.012 mm., in which the largest embryos at the ends appeared almost ready to break off. In the daughter sporocyst of *C. modicella* shown in figure 16 the largest germinal mass was 0.072 by 0.020 mm. while the smallest had only four components and was less than 0.020 mm. in length. Some of the germinal masses were still small in daughter sporocysts which contained a considerable number of free cercarial embryos. An example of this was a daughter sporocyst of *D. flexicaudum,* 0.80 by 0.12 mm., in which there were 22 germinal masses and 25 embryos, the largest of which was 0.050 by 0.025 mm. About two-thirds of its germinal masses were fully developed measuring from 0.07 to 0.09 mm. in length; the others were considerably smaller with the smallest about 0.30 mm. in length with only 4 or 5 components. Almost mature and mature daughter sporocysts, in which there were fully developed cercariae, contained a few small germinal masses 0.035 to 0.045 mm. in length. In older daughter sporocysts no small undeveloped germinal masses could be found, but even in those that appeared to have passed the peak of cercarial production there were numerous very small embryos and germinal cells still present in the germinal masses. It was only in the very oldest infections that any considerable reduction in reproductive activity could be noted. In some of the largest sporocysts from such infections the numbers of the germinal masses appeared to be reduced and some of them had only multicellular components.

DISCUSSION AND SUMMARY

Our recent studies on the germinal development in the sporocysts of strigeoids have confirmed the earlier work of Cort and Olivier (1941). The germinal masses

PLATE II. Stages in the development of strigeoid daughter sporocysts.
FIG. 11. Young embryo daughter sporocyst of *D. flexicaudum,* 0.113 by 0.050 mm.
FIG. 12. Section of part of young embryo daughter sporocyst of *D. flexicaudum.*
FIG. 13. Embryo daughter sporocyst of *C. modicella,* 0.20 by 0.08 mm.
FIG. 14. Embryo daughter sporocyst of *D. flexicaudum,* 0.27 by 0.06 mm.
FIG. 15. Embryo daughter sporocyst of *D. flexicaudum,* 0.33 by 0.07 mm.
FIG. 16. Free young daughter sporocyst of *C. modicella,* 0.30 by 0.07 mm.

of mother sporocysts belonging to this group are discrete structures consisting of a few germinal cells and embryos in early stages of development. The largest embryos are attached at the ends and may contain as many as 6 to 8 germinal cells. After breaking away from the germinal masses the free daughter sporocyst embryos increase in size and at the same time the number of their germinal cells also increases. As they begin to elongate the germinal cells develop into germinal elements of two to five cells, which resemble those found in the rediae of *Clinostomum* (Cort, Ameel, and Van der Woude, 1950). In slightly older daughter sporocysts each of these germinal elements develops into a germinal mass and no more free germinal cells can be found. This development of the germinal masses in the daughter sporocysts is like that described earlier for strigeoid mother sporocysts (Cort, Ameel, and Van der Woude, 1951).

The development of the germinal masses from the germinal cells in the daughter sporocyst is not synchronous. In stages in which no free embryos are present, the largest germinal masses appear to be fully developed while the smallest have only 4 or 5 components. This lag in the development of a part of the germinal masses is still present in daughter sporocysts containing large numbers of free cercarial embryos. However in mature sporocysts, from which numerous cercariae are escaping, all the germinal masses are fully developed and appear to be producing embryos. In old infections there is usually a reduced number of germinal masses in the daughter sporocysts, and a reduction in the number of germinal cells in them.

It is evident, therefore, that the mechanism of germinal development in the germinal sacs of the strigeoids is adapted for the production of large numbers of cercariae over a long period of time. Cercariae are escaping in numbers from the oldest daughter sporocysts before the germinal masses in the mother sporocyst have completed the production of new daughter sporocyst embryos. It appears, therefore, that the number of daughter sporocysts that develop in the snail host is limited by the space and food available in its digestive gland and not by the reproductive potential of the mother sporocyst. Also, the lack of synchronicity in the development of the germinal masses of the daughter sporocysts increases considerably the length of the period during which they can continue to produce cercarial embryos. Therefore, the mechanism of multiplication of germinal cells that has evolved in the Strigeoidea is one of the most effective in producing large numbers of individuals of any found among the digenetic trematodes. The mother sporocyst can continue to produce daughters until the digestive gland of even the largest snail host is filled, and the daughters appear to be able to produce cercariae as long as the snail host lives.

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NAGMIA FLORIDENSIS, N. SP., AN ANAPORRHUTINE TREMATODE FROM THE COELOM OF THE STING RAY *AMPHOTISTIUS SABINUS*

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In a paper reviewing, and in some cases emending the diagnoses of the various genera of the subfamily ANAPORRHUTINE, family GORGODERIDAE, Nagaty (1930) described a new worm from the spiral valve of a species of *Trygon,* collected at the Pearl Banks of Ceylon. Inasmuch as this fluke appeared generically distinct from any described previously, it was given the name *Nagmia yorkei.* This species is the one reproduced in Pl. 2, representing the genus *Nagmia.* A certain amount of confusion exists in the literature regarding the status of this genus since its rejection by T. H. Johnston (1934) as a synonym of *Petalodistomum.* A worm which appears to be a new species of *Nagmia* is here described as *Nagmia floridensis,* with the hope that it may aid in clarifying this situation. A single specimen was obtained some years ago from the coelom of a ray, *Amphotistius sabinus,* at Lemon Bay near Sarasota, Florida. The worm was extended under moderate pressure, fixed in Gilson's fluid and stained with borax-carmine.

Nagmia floridensis, n. sp.

Specific diagnosis: With the characters of the genus *Nagmia.* Ratio of oral to ventral suckers 2 : 3. Esophagus conspicuous, intestinal caeca saccate or moderately branched. Sexually mature specimen 11.5 mm. long and 9.5 mm. in greatest width. Testes extracaecal, lobate; 18 and 30 follicles in the two testes of the type specimen. Ducts of three orders unite testis follicles with vasa efferentia. Vas deferens short, differentiated into seminal vesicle and pars prostatica anteriorly. Ovary entire, oval in shape. Vitellaria loosely arranged, with long digitiform branching processes. Ova 48–60 $\mu \times 37.5$–42 μ.

Host: *Amphotistius sabinus*
Habitat: coelomic cavity
Locality: Lemon Bay, Florida
Type specimen: U. S. National Museum Helminthological Collection, Number 36946.

DESCRIPTION

The shape of the specimen is shown in Fig. 1. An indentation in the midline posteriorly marks the site of the excretory pore. The excretory bladder could not be traced. The oral sucker is terminal in position, 0.80 mm. across by 0.35 mm. long, with the mouth opening on the ventral side. The acetabulum, approximately one-third of the body length from the anterior end, is 1.17 mm. across by 1.24 mm. long.

The pharynx is nearly spherical and fits into a concavity on the posterior wall of the oral sucker. It is strongly muscular, and measures 0.45 mm. in diameter. The thin-walled and fairly straight esophagus is 0.56 mm. long by a maximum of 0.35 mm. wide. The intestinal caeca extend, somewhat more than halfway in from the sides of the body, almost to the posterior end. They are saccate or branched in a highly irregular manner.

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The testes, which are elongated follicular masses with a long axis approximately one-fifth the body length, are extracaecal in the posterior two-fifths of the body. The left testis, somewhat posterior to the right, has thirty follicles; the right but eighteen. The follicles are moderately lobed, the lobulations varying from two to six in number; the follicles average 0.32 mm. by 0.23 mm. in diameter. The duct system uniting the testis follicles is complex and three orders of collecting tubules are present (Fig. 2). The vas efferens divides to form anterior and posterior primary ducts, which in turn give off ducts of a secondary order; the individual follicles finally connect to the secondaries by ducts of a tertiary order. The vasa efferentia, leaving the testes, turn anteriorly, passing just inside the vitelline glands, and unite near the midline a short distance anterior to the ventral sucker. There the vas deferens, a tubule about 75 μ in diameter, is formed. It becomes enlarged to a diameter of 100 μ to 125 μ, to form the seminal vesicle, the anterior end of which, surrounded by prostate glands, may be distinguished as a pars prostatica. The whole of the vas efferens is a slightly curved tubule 1.26 mm. in length, opening with the terminal end of the uterus at a genital pore a short distance posterior to the intestinal bifurcation.

The ovary is entire, oval and measures 0.41 mm. by 0.35 mm. It is situated in the midline, about equidistant from the anterior and posterior ends of the body. Anterolateral to the ovary is the thin-walled seminal receptacle, slightly irregular in outline and measuring 1.08 mm. in length by 0.99 mm. in breadth; this organ is partly filled with spermatozoa. Lateral to the ovary and seminal receptacle, on either side, and lying partly medial, partly ventral to the intestinal caeca, are the vitelline glands (Fig. 3). These glands are rather loosely arranged, with long digitiform branching processes. The left vitellarium is the larger, measuring 1.0 mm. in width by 0.82 mm. in length, while the right is but 0.67 mm. by 0.61 mm. Vitelline ducts lead from the glands to a small reservoir situated immediately posterior to the Mehlis' gland. The latter structure is broadened, somewhat indistinct in outline, measuring about 0.28 mm. by 0.24 mm. The relationships between ovary, seminal receptacle, vitelline reservoir and oviduct are obscure in this specimen. The oviduct passes to Mehlis' gland, where there is apparently a slight enlargement to form an oötype. Leaving Mehlis' gland the duct enlarges, forming the uterus which runs laterally for a short distance, and then posteriorly among the ascending uterine folds. The descending limb of the uterus passes down the left side of the uterine mass, and the ascending limb, complexly coiled, fills most of the intracaecal space posterior to the ovary. It passes on the right side of that organ, and ascends between the acetabulum and the right intestinal caecum to the genital pore. The eggs become considerably enlarged during their passage through the uterus, and these in its terminal parts measure 48–60 μ by 37.5–42 μ, with an average of 53 μ by 38 μ.

DISCUSSION

The establishment of the family Gorgoderidae (Looss, 1902) was a part of the monumental revision of the genus "*Distomum*" undertaken by Artur Looss and others at the turn of the century. In 1899 Looss stated that this genus corresponded in reality to a family, and accordingly set up several subfamilies including the Gorgoderinae. In 1900 von Ofenheim proposed the generic name *Anaporrhutum* for two forms, *Distomum albidum* Brandes from the pericardium and coelomic

cavity of the ray *Aetobatis narinari,* and *D. richiardii* Lopez from the coelom of the shark *Scyllium.* These two species, with a worm from the rectum and urinary bladder of sea turtles which Braun (1899) had redescribed as *Phyllodistomum cymbiforme,* Looss (1901) placed in a new subfamily, the ANAPORRHUTINAE. In the same paper he pointed out that *P. cymbiforme* differed in certain fundamental respects from other phyllodistomes described by Braun, and renamed it *Plesiochorus cymbiforme.* The close relationship between GORGODERINAE and ANAPORRHUTINAE was recognized by Looss, who in 1902 proposed the inclusion of the two groups in a separate family, the GORGODERIDAE. The subfamilies are readily distinguished. The GORGODERINAE exhibit neither pharynx nor seminal receptacle, while these structures are always found in the ANAPORRHUTINAE. Laurer's canal is characteristic of the GORGODERINAE, but not the ANAPORRHUTINAE. The various genera of anaporrhutinae trematodes are figured diagrammatically in Plate 2. For the sake of clarity the uterus has been omitted in each drawing.

Anaporrhutum was broken down into two genera by Looss (1902). *A. albidum,* designated in 1901 as the type species of the genus, has subdivided testes, partly intracaecal and partly extracaecal in position, from which vasa efferentia arise, to be united below the ovary by a cross-connecting tubule before running separately to the seminal vesicle anterior to the ventral sucker. In *A. richiardii* the divided testes are entirely extracaecal, and their vasa efferentia have no cross-connections, but run straight to the seminal vesicle. Accordingly, a new genus *Probolitrema* was suggested for the species *P. richiardii.*

Two species belonging to a new genus, *Petalodistomum,* were described by S. J. Johnston (1913). Both were found in the coelom of the ray *Dasyatis kuhlii.* The type species, *P. polycladum,* is characterized by slightly branched intestinal caeca and excretory bladder and highly lobulated extracaecal testes which may be single or divided into as many as three separate masses. The second species, *P. cymatodes,* which Johnston described, differs from the first in that the testes consist of many minute follicles arranged extracaecally in a linear manner with short ducts leading directly to the vasa efferentia. The intestinal caeca are undulating but unbranched. Travassos (1922) proposed that the latter worm be given the generic name *Staphylorchis.* The only other genus of anaporrhutine flukes which has been described to date is *Nagmia.*

As mentioned above, T. H. Johnston (1934) rejected *Nagmia* as a synonym of *Petalodistomum.* Nagaty stated that *Nagmia* differs from *Petalodistomum,* to which it is most closely related, by its greater size, in the shape and relative position of the vitelline glands, and in the greater lobulation of the testes. Size certainly cannot be considered of any significance as a generic character, as Johnston rightly points out. Nagaty seems to have been in error regarding the structure of the vitelline glands in *Petalodistomum,* which he stated consists of "two sets of small rounded follicles". Johnston figured the type specimen of *P. polycladum* (see Pl. 2), with two quite compact masses, each of which "has about forty or fifty small rounded projections". He characterized these as "short tubular processes". Nagaty in his description of the vitellaria of *N. yorkei* stated that "Each gland is composed of many tubules, numbering from about twenty to thirty; from four to ten of these unite together and form a main stem. Three or four such stems are formed in all and these unite together". The same situation obtains in *N. floridensis,* although some of the "main stems" are composed of but one or two elongated tubules. As will be seen later,

another species of *Nagmia, N. pacifica,* may show some intergradation between the compact form of *Petalodistomum* and the looser form of vitelline structure typical of *N. yorkei.* The difference in position of the vitellaria in the two genera is probably not of generic significance, but in *Petalodistomum* the vitellaria are very close to the ovary and seminal receptacle, and may underlie parts of these organs, while in Nagaty's figure of *N. yorkei* the right vitellarium, and in *N. floridensis* and *N. pacifica* both vitellaria are well lateral in position, with long ducts to the reservoir.

Nagaty's characterization of the structure of the testes in *Nagmia* is perhaps unfortunate, in indicating that they differ from those of *Petalodistomum* only by virtue of more extreme lobulation. This is not actually the case in *P. polycladum,* as it possesses from one to three large testis masses, connecting directly by short ducts to the vasa efferentia. In *N. yorkei* there are from twenty-nine to thirty-five separate follicles in each testis, and in *N. floridensis* eighteen and thirty, which are connected to the vas efferens by three orders of ducts. This is not deeper lobulation, but actual separation of the testis into many discrete parts, analogous to that seen in *Probolitrema, Anaporrhutum* and *Staphylorchis,* and in the subfamily Gorgoderinae, in *Gorgodera.* In all these cases such separation is considered to be of generic significance.

In the nomenclature of the male ducts, both Nagaty and Johnston, as well as Stunkard (1935) and Woolcock (1935) with *Probolitrema,* consider the vasa efferentia to be those ducts which join the testis follicles together; the main ducts from the testes which come together near the midline anteriorly, they call vasa deferentia. In all forms with compact testes, these two ducts would be considered vasa efferentia, and the common tubule formed by their junction the vas deferens. It seems best so to consider them, and to designate the tubules connecting the follicles as primary, secondary and tertiary connecting tubules. The vas deferens, then, extending medially from the junction of the two vasa efferentia, is expanded anteriorly into a seminal vesicle and pars prostatica.

In 1945 Caballero described as *Petalodistomum pacificum* a worm from the coelom of a shark (species undetermined) from Mexican Pacific waters. Caballero reviewed Nagaty's work and, in agreement with Johnston, considered *Nagmia* to be a synonym of *Petalodistomum.* Caballero's drawing shows that his species possesses loosely branching digitiform vitelline glands, and lobate follicular testes, united by a complex duct system. In a personal communication, Caballero states that the vitellaria actually range in structure from the very loose form which he figured to a compact structure such as described for *Petalodistomum polycladum.* In the above discussion I have considered Caballero's species as congeneric with *Nagmia yorkei* and *N. floridensis;* its name thus becomes *Nagmia pacifica* (Caballero).

Nagmia yorkei is the only anaporrhutine described from elasmobranchs which has been found in any site other than the body cavity. Nagaty's specimens were "found in a bottle which also contained a number of cestodes," and it is possible

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Explanation of Plates

Plate 1

Fig. 1. *Nagmia floridensis,* whole mount.
Fig. 2. Testis of *N. floridensis,* showing the tubule system uniting to form the vas efferens.
Fig. 3. Vitelline gland of *N. floridensis.*

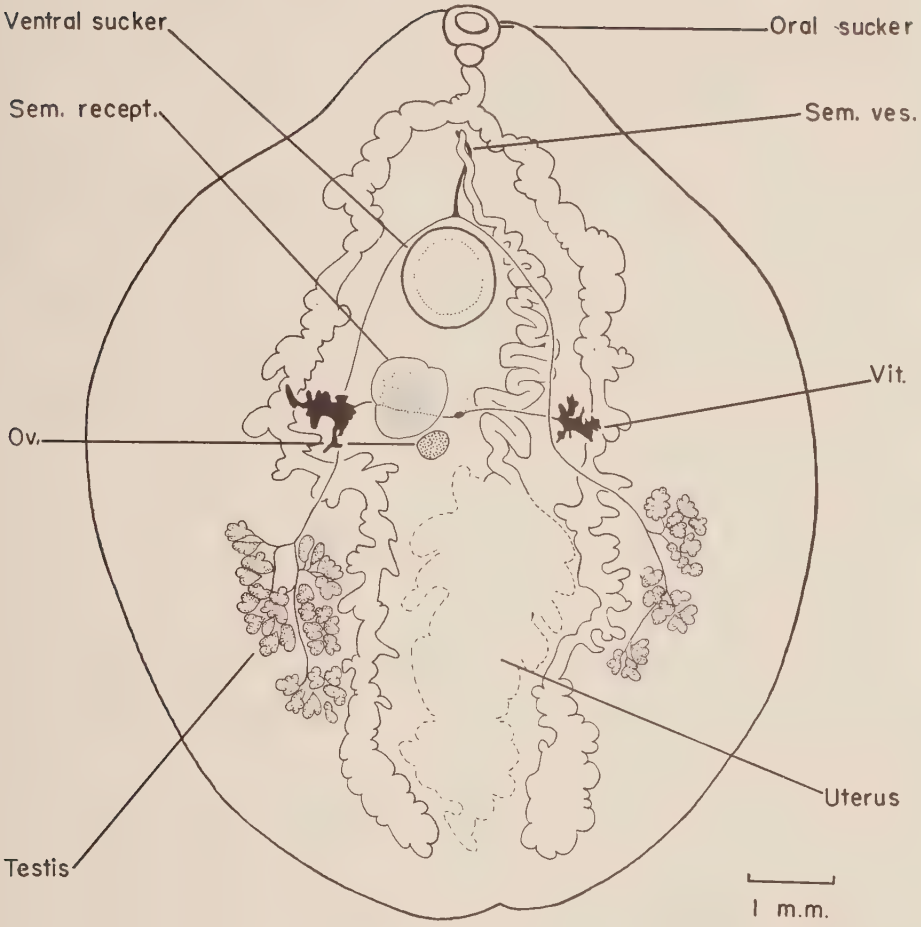

FIG. 1

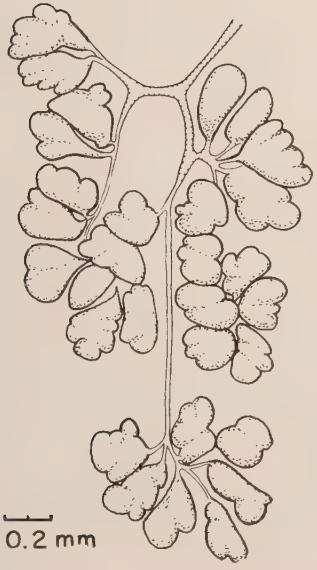

FIG. 2

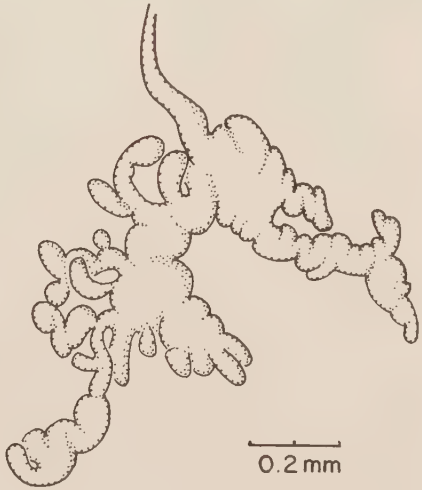

FIG. 3

that the original collector (unnamed) was in error regarding their site of origin in the host.

Nagaty's diagnosis of the genus *Nagmia* must be modified as follows: Large Anaporrhutinae with the lateral and posterior borders forming nearly a semicircle. A muscular pharynx is present; the esophagus may be present or absent. Intestinal caeca branched. Testes extracaecal, follicular; the individual testis follicles united together by a series of ducts leading into the vasa efferentia. Vitelline glands intracaecal. A large receptaculum seminis is present.

Nagmia floridensis differs from *N. yorkei* in the shape and position of the ovary, this organ being lobed and to one side of the midline in the latter species, in possessing a longer esophagus, in having less highly sacculated intestinal caeca, and in having smaller testis follicles. *Nagmia pacifica* differs from both other species in the apparent total absence of the esophagus, the rudimentary nature of its intestinal sacculations, and in having larger and less numerous testis follicles.

SUMMARY

1. *Nagmia floridensis,* an anaporrhutine trematode from the coelom of the ray *Amphotistius sabinus* from the west coast of Florida, is described, and compared with related species.

2. The question of the synonymy of *Nagmia* and *Petalodistomum* is considered, and the identity of the genus *Nagmia* reaffirmed. *Petalodistomum pacificum* Caballero is referred to the genus *Nagmia.*

3. A revision of the nomenclature of the male ducts in this group is suggested.

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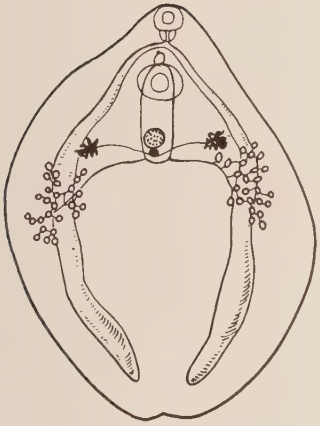
Plate 2

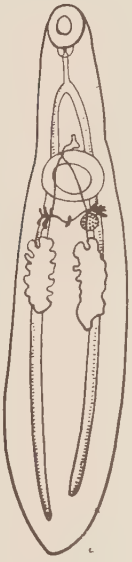
The Subfamily Anaporrhutinae. Diagrammatic representations of the different genera, from various sources.

PLATE II

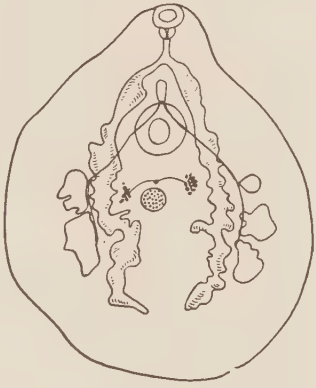
The Subfamily Anaporrhutinae



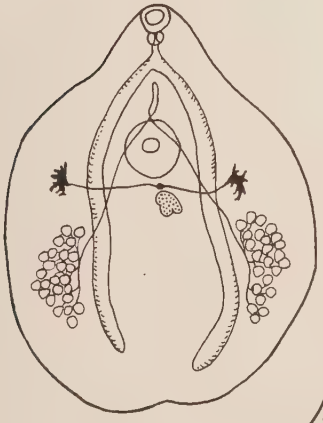
Anaporrhutum



Plesiochorus

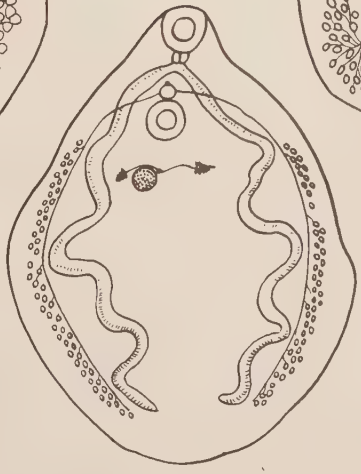


Petalodistomum



Probolitrema

Nagmia



Staphylorchis

INCIDENCE OF BLOOD PARASITES IN BIRDS COLLECTED IN SOUTHWESTERN GEORGIA[1]

Gory J. Love, Sara Ann Wilkin, and Melvin H. Goodwin, Jr.

In connection with studies of the susceptibility of *Anopheles* mosquitoes to avian malarias, surveys were made to determine the incidence of blood parasites of birds in southwestern Georgia. This work was undertaken after the report of high sporozoite rates in *A. crucians* and *A. quadrimaculatus* from an area in South Carolina where human malaria was declining (Sabrosky, McDaniel, and Reider, 1946). Sporozoite rates in that area have remained consistently high, although human malaria has not been demonstrable in the area for more than three years (Atchley, 1952). Since the obvious possibility exists that the sporozoites found in these surveys were not of human origin, it is desirable to determine the available sources of infection. Until the unknown sporozoites are related to specific species, no surveys of plasmodia in *Anopheles* can be evaluated properly. Investigations designed to provide information on this problem have been reported by Hart (1949), Hunninen and Young (1950), and Hunninen, Young, and Burgess (1950). The purpose of the work in the Georgia area was to determine the susceptibility of local *Anopheles* to various malarial parasites in lower animals of the area and to determine if sporozoites were present in wild-caught *Anopheles* in a locality where human malaria had been undetected for longer than in the South Carolina area (Goodwin, 1950). Data on the incidence of blood parasites in various species of birds are presented in this report.

Most birds were obtained by trapping in the vicinity of the station in Baker County, Georgia. During a survey of summer birds of the area, Norris (1951) provided specimens from several adjoining counties: Decatur, Seminole, Early, Clay, Dougherty, Calhoun, Tift, and Macon. Blood films were obtained from 65 mourning doves during the course of a special study of this species by Hopkins and Odum (1952). From June through September 1948 birds were shot as well as trapped when special attempts were made to collect several specimens of species known to be infected with specific parasites and to obtain insectivorous birds that were not taken with grain-baited traps.

Blood was obtained from a leg or toe vein of living birds and from birds that were shot if films could be prepared immediately. Films were made from blood obtained from the heart in other instances. During the special survey for insectivorous species, birds were shot and the thorax opened as quickly as possible. Incisions were made into the heart and lungs, and the thoracic cavity was then washed with about 5 cc. of heparinized saline. The fluid in the cavity was then aspirated into a syringe and expelled into a sterile rubber-capped vaccine vial. A blood film was made from the residual material in the syringe. The vial was kept refrigerated until it was returned to the laboratory where inoculations into *Plasmodium*-free canary birds were made. Periodic checks were made on the viability of parasites handled

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[1] From the Communicable Disease Center, Public Health Service, Federal Security Agency, Atlanta, Georgia and Emory University Field Station, Newton, Georgia.

in this manner by sacrificing birds with latent infections and obtaining inoculum in the manner described, before leaving the laboratory in the morning. Upon returning in the evening a canary bird was injected after material from the wild birds had been processed. None of the control inoculations failed to produce infections.

Blood films were stained with Giemsa and examined with an oil immersion lens. The minimum time of examination for each film recorded as negative for parasites was ten minutes.

From April 1947 through February 1952 a total of 1,246 birds, representing 97 species, was examined. Of these, 1,092 were examined by direct blood films only. Blood from each of the remaining 150 birds was injected into parasite-free canary birds. Tables 1 and 2 indicate results of all examinations. In table 1 the incidence of the major group of parasites and species of *Plasmodium* encountered are shown for the various species of hosts. Table 2 is a list of birds in which no parasites were demonstrated.

The species of *Plasmodium,* as well as other parasites, encountered have been reported from the general region where this study was conducted (Jordan, 1943; Thompson, 1943). The present study included several more species than were examined by these writers and 30 new host records were established. Species from which parasites were previously unreported, based on the lists of Herman (1944), Hart (1949), and Hunninen and Young (1950) are indicated by asterisk in table 1. Ten new records are given for *Plasmodium,* 14 for *Haemoproteus,* 4 for *Trypanosoma,* and 2 for *Leucocytozoon.*

Only two birds were found to have latent infections by inoculation of blood into canaries when parasites were not demonstrable in the peripheral blood. *Plasmodium elongatum* was detected in a canary inoculated from a cardinal and a double infection of *P. circumflexum* and *P. relictum* or *P. cathemerium* developed in a canary inoculated from a mockingbird.

Microfilaria were detected four times as frequently in films made from blood in the heart than from the peripheral circulation.

CONCLUSION

Infectivity of some avian plasmodia to *Anopheles* mosquitoes has been demonstrated by several investigators (Hunninen, Young, and Burgess 1950). The present study and other surveys indicate that malaria infections in birds are common in areas where anophelines are present. Ecological information concerning relations of vertebrate and invertebrate hosts is insufficient for epidemiological evaluation of the possibility of natural avian-malaria transmission by *Anopheles.* On the basis of existing information, however, the finding of avian malaria sporozoites in *Anopheles* could be expected. Further studies are needed on the natural history of avian malarias and on the infectivity of sporozoites from wild-caught anophelines.

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TABLE 1.—*Incidence of blood parasites in birds examined from southwestern Georgia*

Hosts					Parasites								
					Plasmodium								
Family and specific name	Common name	No. examined	No. positive	No. canary inoculations	*relictum or cathemerium*	*elongatum*	*circumflexum*	*hexamerium*	unidentified	*Haemoproteus*	*Leucocytozoon*	*Trypanosoma*	Microfilariae
Colymbidae													
Podilymbus p. podiceps	Pied-billed Grebe	5	1	5						1*			
Ardeidae													
Butorides v. virescens	Eastern Green Heron	2	1	2						1*			
Florida c. coerulea	Little Blue Heron	2	1	2						1*			
Nyctanassa violacea	Yellow-crowned Night Heron	2	1	1						1*		1*	
Threskiornithidae													
Guara alba	White Ibis	1	1	1						1*			
Cathartidae													
Cathartes aura	Turkey Vulture	4	1	1						1			
Buteoninae													
Buteo lineatus	Red-shouldered Hawk	4	2							2			
Falconinae													
Falco sparverius	Sparrow Hawk	1	1							1			
	Unidentified Hawks	1	1						1				
Meleagrididae													
Meleagris gallopavo	Wild Turkey	2	1							1*			
Columbidae													
Zenaidura macroura	Mourning Dove	65	16	1						16			
Picidae													
Centurus carolinus	Red-bellied Woodpecker	24	14	12						13*			1
Dendrocopus villosus	Hairy Woodpecker	4	2	3						2*			
Dendrocopus pubescens	Downy Woodpecker	3	1	1						1			
Tyrannidae													
Tyrannus tyrannus	Eastern Kingbird	7	4	5						1*			3
Hirundinidae													
Progne s. subis	Purple Martin	1	1	1						1			
Corvidae													
Corvus brachyrhynchos paulus	Southern Crow	15	5		1					5			4
Cyanocitta c. cristata	Blue Jay	87	52	17	6		2			48	1	1	7
Paridae													
Parus carolinensis	Carolina Chickadee	1	1								1*		
Sittidae													
Sitta pusilla	Brown-headed Nuthatch	5	1								1*		
Troglodytidae													
Thryothorus ludovicianus	Carolina Wren	12	4	3					2*				2
Mimidae													
Mimus p. polyglottos	Mockingbird	36	9	16a	2		1*		2	7			1
Toxostoma r. rufum	Brown Thrasher	24	4	2		2			1	1			

TABLE 1.—*Continued*

Hosts					Parasites								
					Plasmodium								
Family and specific name	Common name	No. examined	No. positive	No. canary inoculations	*relictum* or *cathemerium*	*elongatum*	*circumflexum*	*hexamerium*	unidentified	*Haemoproteus*	*Leucocytozoon*	*Trypanosoma*	*Microfilariae*
Turdidae													
Hylocichla guttata faxoni	Hermit Thrush	10	3			1*				3			
Sialia s. sialis	Eastern Bluebird	6	1	2									1
Sylviidae													
Polioptila c. coerulea	Blue-gray Gnatcatcher	4	1	3	1*							1*	1
Vireonidae													
Vireo flavifrons	Yellow-throated Vireo	6	3	1			1*			2*			
Vireo griseus	White-eyed Vireo	3	1										1
Vireo sp.	Unidentified Vireo	4	1		1*					1*			
Parulidae													
Dendroica discolor	Prairie Warbler	4	1										1
Dendroica dominica	Yellow-throated Warbler	2	1	1						1			
Dendroica p. pinus	Pine Warbler	19	4	5	2*					4*			
Mniotilta varia	Black and White Warbler	3	1	2								1*	
Oporornis formosus	Kentucky Warbler	4	2										2
Parula americana	Parula Warbler	8	5	1	1*		1			3*		2*	
Protonotaria citrea	Prothonotary Warbler	1	1										1
Icteria v. virens	Yellow-breasted Chat	1	1							1			1
Ploceidae													
Passer d. domesticus	English Sparrow	250	43		35	5	1		4	1			
Icteridae													
Icterus spurius	Orchard Oriole	10	3	1				1*	2				
Agelaius phoeniceus	Red-winged Blackbird	8	2										2
Quiscalus quiscula	Purple Grackle	12	4	2					1	2			1
Molothrus a. ater	Eastern Cowbird	35	2						2				
Thraupidae													
Piranga r. rubra	Summer Tanager	11	3	2						3*			
Fringillidae													
Richmondena c. cardinalis	Cardinal	154	72	16[b]	23	13	4		11	33	1	3	7
Ammodramus savannarum	Grasshopper Sparrow	14	1		1*					1			
Poocetes g. gramineus	Vesper Sparrow	30	1			1				1			
Spizella p. passerina	Chipping Sparrow	48	10		2					8			
Spizella p. pusilla	Field Sparrow	37	9		6	4				2			1
Zonothrichia albicollis	White-throated Sparrow	38	11						3	7			
Melospiza melodia	Song Sparrow	13	2		2								
Pipilo erythrophthalmus	Towhee	25	8	4					1				7
	Totals	1068	322	113	83	26	10	1	30	178	4	9	44

* Indicates new host record.

[a] One bird developed infection of *P. circumflexum* and *cathemerium* or *relictum*.

[b] One bird developed infection of *P. elongatum*.

TABLE 2.—*Birds from southwestern Georgia found negative for blood parasites*

Family and specific name	Common name	Number examined	Number canary inoculations
Phalacrocoracidae			
Phalacrocorax auritus	Cormorant	3	
Ardeidae			
Casmerodius albus egretta	American Egret	2	
Ardea herodias	Great Blue Heron	1	1
Anatidae			
Aix sponsa	Wood Duck	3	
Lophodytes cucullatus	Hooded Merganser	1	
Carhartidae			
Coragyps atratus	Black Vulture	1	
Phasianidae			
Colinus virginianus	Eastern Bob-white	26	2
Rallidae			
Fullica americana	American Coot	1	
Gallinula chloropus cachinnans	Florida Gallinule	3	2
Porphyrula martinica	Purple Gallinule	1	
Scolopacidae			
Erolia minutilla	Least Sandpiper	2	
Tringa s. solitaria	Solitary Sandpiper	4	3
Charadriidae			
Charadrius hiaticula semipalmatus	Semipalmated Plover	1	
Charadrius v. vociferos	Killdeer	6	3
Columbidae			
Columbigallina p. passerina	Ground Dove	9	1
	Unidentified Dove	2	
Cuculidae			
Cuccyzus a. americanus	Yellow-billed Cuckoo	1	1
Caprimulgidae			
Chordeiles minor	Night Hawk	1	
Trochilidae			
Archilochus colubris	Ruby-throated Hummingbird	1	
Picidae			
Colaptes a. auratus	Southern Flicker	5	2
Denorocopus borialis	Red-cockaded Woodpecker	3	1
Melanerpes erythrocephalus	Red-headed Woodpecker	2	1
Tyrannidae			
Contopus virens	Wood Pewee	1	1
Empidonax virescens	Acadian Flycatcher	2	
Myiarchus crinitus	Crested Flycatcher	5	4
Sayornis phoebe	Phoebe	5	
Hirundinidae			
Stelgidopteryx ruficollis serripennis	Rough-winged Swallow	1	
Paridae			
Parus bicolor	Tufted Titmouse	7	6
Parus sp.	Chickadee	3	2
Sittidae			
Sitta carolinensis	White-breasted Nuthatch	1	
Certhiidae			
Certhia familiaris	Brown Creeper	1	
Troglodytidae			
Thryomanes bewickii	Bewick's Wren	2	
Turdidae			
Hylocichla mustelina	Wood Thrush	1	
Sylviidae			
Regulus s. satrapa	Golden Crowned Kinglet	2	
Regulus c. calendula	Ruby Crowned Kinglet	2	
Laniidae			
Lanius ludovicianus	Loggerheaded Shrike	8	3
Vireonidae			
Vireo solitarius	Blue Headed Vireo	1	
Parulidae			
Seiurus motacilla	Louisiana Water Thrush	1	
Dendroica c. coronata	Myrtle Warbler	4	
Dendroica palmarum	Palm Warbler	3	
Wilsonia citrina	Hooded Warbler	1	1
Geothlypis trichas	Yellow Throat	16	
Icteridae			
Sturnella magna	Meadowlark	2	2
Fringillidae			
Guiraca c. caerulea	Eastern Blue Grosbeak	2	
Spinus t. tristis	Eastern Goldfinch	1	
Aimophila aestivalis	Pinewoods Sparrow	7	1
Melospiza georgiana	Swamp Sparrow	5	
Passerculus sandwichensis	Savannah Sparrow	15	
Totals		178	37

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PARASITES OF BISON IN NORTHWESTERN U. S. A.[1]

BETTY LOCKER[2]

During the winter of 1951–1952, herd reductions were carried out at the National Bison Range at Moiese, Montana, and at the Yellowstone National Park Bison Ranch in Wyoming. Facilities were available at both places for satisfactory parasitological investigations of the bison as they were butchered. The specimens collected at Moiese are listed in Table 1; these data are more truly representative of the species present than of their numerical incidence.

The *Hypoderma* larvae from bison at Moiese, Montana, listed in Table 1, were first or second stage larvae lying under the muscle layer surrounding the esophagus. In addition to these early forms, dead and discolored larvae from previous years'

TABLE 1.—*Parasites present in Bison at Moiese, Montana*

HOST	ENDOPARASITES					
	Helminths					Dipterous Larvae
	Fasciola hepatica	*Moniezia benedeni*	*Dictyocaulus viviparus**		*Trichuris ovis***	*Hypoderma* sp.***
MOIESE BISON						
Sex & Age						
♂-1 year	0	1	7♂♂	10♀♀	4♀♀	0
♂-2	0	0	0		—	12
♂-2	0	0	0		—	0
♀-8	0	6	0		—	0
♀-10	0	0	0		—	4
♀-10	0	3	0		—	0
♀-25	0	4	0		—	3
♀-30	7	2	2♂♂	7♂♂	—	Present

* Syn. *D. hadweni*.
** Identification based upon females only. Dashes indicate that examinations were not made for this parasite.
*** Probably *H. lineatum*.

infections could be discerned beneath the hide on the backs of bison as they were skinned. Many animals showed warble infestation at both sites; bison born the previous spring were exempt from the older back wounds, of course, but had the esophageal larvae. Considering the thick hide and extremely compact hair of these mammals, it might be postulated that many of the mature larvae lying along the back had been unable to emerge because of the mechanical difficulty involved. However, Scharff (1950), reported that *Hypoderma* larvae in Montana cattle very often died beneath the hide on the back without emerging. It would appear that other factors might be involved in the unsuccessful completion of this life cycle in Montana bovids.

The liver flukes, *Fasciola hepatica* Linnaeus, 1758, lay in the main bile ducts of the liver; necrotic areas or walled off abscesses such as occur in sheep during fascioliasis were not observed.

This herd roams over a fence-enclosed area of approximately 18,540 acres which consists of high grassland, timber, and drainage areas that have cattail-bordered watering holes. Cattle ranches closely adjoin the Range.

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[1] From the Federal Security Agency, Public Health Service, National Institutes of Health, National Microbiological Institute.

[2] Rocky Mountain Laboratory, Hamilton, Montana.

The Yellowstone herd, on the other hand, is allowed to move freely over the northeast corner of the Park, restricted only by drift fences and the natural topography of the land. Only one species of parasite, a tapeworm, was found in these animals, which are geographically isolated from domestic stock and have a more natural habitat than the Moiese bison. This tapeworm, *Moniezia benedeni* (Moniez, 1874), occurred randomly among all age groups. Fourteen were recovered from a 2-year-old male bison; however, one, two or three were the more usual numbers in a parasitized animal.

It is interesting to note that the wider range of parasites came from the Moiese herd living in a fenced area, which has definite watering "holes" used since the Range was occupied in 1909, and which is in close proximity to domestic bovids.

M. benedeni is the only parasite that appeared consistently at nearly all age levels in both herds. *Hypoderma* larvae although present in the Moiese bison were not found in the Yellowstone bison and have never been seen there according to Mr. H. Helgeson who has supervised slaughter of bison from these herds for approximately 27 years.

Such parasites as *Haemonchus contortus* in the abomasum and *Oesophagostomum radiatum* along the mysenteries were looked for specifically during this study but were not encountered.

Cameron (1923, 1924) reported, "*Hypoderma* sp., *Setaria labiatopapillosa, Fasciola magna, Hoemonchus ostertagi, Dictyocaulus filaria, Moniezia* sp., *Esophagostomum* sp., and *Sarcocystis*." from Bison in Canada. Roudabush (1936) listed, "*Haemonchus contortus, Dictyocaulus hadweni, Oesophagostomum radiatum, Moniezia benedeni, Hypoderma lineatum,*" from *Bison* in Oklahoma. Frick (1951) found *Dictyocaulus viviparus, Oesophagostomum radiatum,* and *Haemonchus contortus,* in a bison herd in Kansas. Dikmans (1934) recorded *Moniezia benedeni* occurring in western bison from material supplied him by R. R. Parker.

No ectoparasites were observed during this survey. Glen M. Kohls (1952) has reported *Dermacentor andersoni* from a private bison herd that was pastured with cattle near the Moiese Range. Roudabush (1936) listed "*D. nigrolineatus*" (= *D. albipictus*) from bison in Oklahoma; Cameron (1923, 1924) reported no external parasites from the Canadian herd.

Blood samples from these bison were taken by C. B. Philip for serological examination. Information on these tests will be published at a later date.

The author wishes to thank J. T. Lucker and C. G. Durbin at the Agricultural Experiment Station, Beltsville, Md., for the identification of the nematodes. The cordial cooperation of our state and federal people associated with the bison herds, was particularly appreciated during the field work for this paper.

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THE LIFE CYCLE OF *METAGONIMOIDES OREGONENSIS* PRICE (TREMATODA: HETEROPHYIDAE)[1]

WM. C. BURNS[2] AND IVAN PRATT[3]

Metagonimoides oregonensis, a heterophyid trematode parasitizing the small intestine of the racoon, *Procyon lotor pacifica* Merriam, was described by Price (1931). Ingles (1935) briefly described the larval stages of a fluke in the apical organs of *Goniobasis nigrina* (Lea). He concluded, correctly it would appear, that the fluke was *Metagonimoides oregonensis.* Ingles reported that there was no free-swimming cercarial stage in the life cycle of this trematode, and observed that the cercariae developed directly into metacercariae within the redia.

This investigation was undertaken to determine the fate of the cercariae and the metacercariae, and to describe subsequent stages in the life history of this fluke. Some additions to the original description of the adult are included.

METHODS AND MATERIALS

Infected *Goniobasis silicula* (Gould) were collected from Rock Creek, two miles west of Philomath, Benton County, Oregon, and from the mouth of Big Creek at Sunset Bay State Park, two miles south of Charleston, Coos County, Oregon, during the spring and summer of 1951. The snails were kept in aquaria containing well aerated stream water circulating through a charcoal filter. The temperature of the water was kept at approximately 11° C. by suspending the aquaria in tanks through which flowed cold tap water. Decomposing carrots, celery and maple leaves were used as food for the snails. Snails so treated could be kept alive through the winter in the laboratory.

The leopard frog, *Rana pipiens* Schreber, was used as the experimental intermediate host. The frogs were obtained from Oshkosh, Wisconsin, which minimized the possibility of their being naturally infected with metacercariae of *Metagonimoides oregonensis.* Twenty *Rana pipiens,* not experimentally exposed to cercarial invasion, were examined for heterophyid metacercariae and found to be negative.

The Oregon red-legged frog, *Rana aurora aurora* (Baird and Girard), was found to be the natural host for the metacercaria. Frogs of this species were collected in the spring of 1952 from McFadden's swamp, 12 miles south of Corvallis, Oregon.

Sexually mature flukes were recovered from racoons trapped along Mary's River, near Wren, Benton County, Oregon.

Golden hamsters were used as experimental definitive hosts. The hamsters were kept in standard laboratory cages and fed Purina Laboratory Chow. Adult flukes were recovered from the small intestine of the hamster by agitating the opened intestine in mammalian Ringer's solution.

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[1] Published with the approval of the Oregon State College Monographs Committee, Research Paper No. 210.

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All measurements and most observations were made of living material. Cercariae and metacercariae were often stained with dilute solutions (1 : 5000) of either neutral red or Nile blue A, which would slow body movement without killing the larvae. It was possible to see minute anatomical details by allowing the fluid in which the larvae were suspended to evaporate from under the coverslip, thus compressing the larvae. Metacercariae in frog muscle were fixed in Bouin's fixative, sectioned, and stained with hematoxylin-eosin. Adult flukes were fixed in formalin-acid-alcohol mixture beneath cover slides to flatten them. Whole mounts of adults were stained with Mayer's carmalum; serially sectioned adults were stained with iron-hematoxylin.

Measurements were made with a measuring eyepiece. The *camera lucida* was used to obtain proper proportions; details of anatomy were added to make composite drawings.

DESCRIPTION OF STAGES IN THE LIFE HISTORY

The Adult

Heavy infections of sexually mature *Metagonimoides oregonensis* were recovered from the small intestine of wild racoons and from experimentally infected hamsters. The anatomy of the fluke agrees with the description as given by Price (1931). The forms made available to him were preserved and lacked a cuticle so that he was unable to describe the close-set, fine, scale-like cuticular spines most numerous toward the anterior end.

Only the more conspicuous details of the excretory system were observed (Fig. 1). On either side of the fluke a wide anterior collecting duct united with a narrower posterior duct at the distal extremeties of the lateral arms of the Y-shaped excretory bladder. There were 18 flame cells on each side. A flame cell formula was not erected, as the collecting tubules from the flame cells to the main ducts could not be followed with certainty.

The Egg and Miracidium

The eggs of *Metagonimoides* were small (0.033 mm. by 0.018 mm.), ovoid, and brown, with an operculum at one end and a short, blunt knob at the other. Large numbers of eggs were obtained from adult flukes removed from the small intestine of a wild racoon and from experimentally infected hamsters. The eggs were incubated in open dishes containing filtered stream water kept at room temperature.

Eggs obtained from the uterus contained five large vitelline cells and an equally large ovum (Fig. 2). After 23 days incubation, the egg contained a sluggishly moving, ciliated miracidium (Fig. 3). The miracidium was 0.021 mm. long and 0.012 mm. wide. The anterior end of the larva was conical, the tip lying just behind the operculum of the egg. There was a unicellular gland in the apical region which communicated with the tip of the miracidium by a wide duct. After 120 days incubation, the miracidia in the eggs were identical with those incubated only 23 days.

Placing the eggs in warm water, dilute solutions of HCl, trypsin solutions, and combinations of these failed to produce hatching of the eggs. Whether miracidia hatch in water and penetrate the snail or must be ingested by the molluscan host in order to continue development was not ascertained.

The Redia

Although repeated dissections of *Goniobasis* were made, no sporocyst was ever seen. Mature and immature rediae occurred in large numbers throughout the digestive gland tissue of the snail. Immature rediae never were found to occur within another redia. Snails isolated in an aquarium for periods of four months and longer, and hence kept from re-infection by miracidia, contained large numbers of immature rediae which must have arisen from some generation other than the miracidia.

Redia obtained from the digestive glands of infected snails measured from 0.12 mm. to 1.6 mm. in length and from 0.03 mm. to 0.3 mm. in width. The smallest redia was straight and narrow, possessed a well-developed pharynx 0.035 mm. in diameter, and had a straight intestine that extended through the length of the body. Fully developed rediae were typically sausage-shaped (Fig. 4). The pharynx was the same size as in the immature redia. The intestine was short (0.05 mm.–0.1 mm.) and extended at a right angle to the pharynx. A birth pore, often seen on a raised process, was 0.035 mm. from the anterior end of the body. Cercariae were observed to leave the redia through this opening.

A mature redia contained germ balls, immature cercariae, mature cercariae, intermediate stages of cercariae developing into metacercariae, and mature metacercariae. The intermediate stages of cercariae developing into metacercariae were characterized by degeneration of the tail, loss of the penetration glands, widening of the body, and progressive development of the intestinal ceca and ventral sucker. Metacercariae that developed within rediae were never encysted. The smaller rediae contained more cercariae than they did metacercariae, whereas the larger rediae were filled with metacercariae and contained only a few cercariae or none at all.

Only two snails of several hundred examined were infected with rediae that contained only cercariae.

Infected snails isolated in finger bowls shed only cercariae. However, in one of several hundred examinations, four metacercariae were found free of the snail and dead in a finger bowl. These presumably came from a redia that had ruptured. The apex of the shell of *Goniobasis silicula* is frequently absent. This was true of the snail from which the metacercariae had been shed, and may have provided an exit for the larvae.

The Cercaria

Motile cercariae were readily obtained for study by placing infected snails in finger bowls containing stream water which had been warmed to room temperature. Usually forty or fifty cercariae were shed from a single snail within ten to fifteen minutes following such treatment.

The cercariae of *Metagonimoides oregonensis* belong to the pleurolophocercous group established by Sewell (1922). When the larva was inactive, the body was long and slender and somewhat arched dorsally (Fig. 5). Cercariae stained with Nile blue A assumed a resting position characteristic of larvae in stream water. The body was capable of assuming considerable differences in shape. When contracted, it appeared almost spherical and measured 0.09 mm. in length by 0.06 mm. in width. In an extended condition it was 0.24 mm. long and 0.045 mm. wide. The anterior part of the body was covered with posteriorly-directed spines. The

tail was set deep in a socket at the posterior end of the body. It was twice as long as the body and was provided with a thin, transparent ventral fin fold which extended from the middle of the tail to the tip. The fin was broadest at the end of the tail and imparted a crook to the tip of the tail. The tails of cercariae stained with Nile blue A measured from 0.3 mm. to 0.33 mm. in length and from 0.026 mm. to 0.03 mm. in width. Characteristically, the cercariae swam towards the surface of the water or horizontally, then suddenly stopped and slowly sank to the bottom. Changes in light intensity or slight mechanical agitation stimulated swimming.

The cercariae (Fig. 6) had conspicuous eyespots containing pigment granules. These were located dorso-laterally, 0.066 mm. from the anterior end of the body. Although nearly always a spherical, compact aggregation of granules, an "eyespot" occasionally appeared as an area of scattered pigment granules.

The oral sucker was 0.037 mm. in length and 0.025 mm. in width; the opening was subterminal. The inner dorsal surface of the oral sucker bore two horizontal rows of anteriorly-directed spines, seven spines to a row. These spines were slightly larger than the cuticular spines, but otherwise like them. A long prepharynx extended from the oral sucker to the level of the eyespots, where it joined a small, oblong (0.024 mm. long) muscular pharynx. The pharynx was best seen on unstained cercariae, as it lies ventral to the penetration gland ducts and was obscured when the latter were stained. The intestinal ceca were not present in cercariae shed from their snail host.

The central region of the body contained conspicuous penetration gland cells with large, clear nuclei. These were best observed by staining living cercariae with 1 : 1000 neutral red. There were from 14 to 16 cells arranged in a cluster which extended to the lateral margins of the body. From the anterior edge of the cell mass four broad ducts passed anteriorly between and ventral to the eyespots to a point just behind the oral sucker. Here, each was seen to divide into two ducts that passed dorsal to the sucker and opened to the exterior immediately anterior to the margin of the sucker. Although the openings of the ducts were never seen, numerous observations revealed secretions of a glandular material at from five to eight points where the ducts appeared to end.

A large, thick-walled excretory bladder filled with material resembling oil droplets was located just anterior to the tail socket. The wall of the bladder was often deeply creased and folded upon itself. An excretory duct leading from the bladder to the posterior end of the body was seen after the tail had been cast from the cercaria during penetration. Flame cells were never seen in the body or in the tail of the cercariae.

Undifferentiated cells, probably reproductive anlagen, lay between the excretory bladder and the penetration glands. These were uniformly pink when stained with neutral red, in contrast with the dark red of the penetration glands. The ventral sucker was not present in the cercaria, although it was well developed and in this region in the metacercaria.

Free-swimming cercariae readily penetrated frogs and tadpoles exposed to them. Contact with the host seemed to be chiefly by chance. Frog tissue placed in stream water containing active cercariae did not attract the larvae unless actual contact was made with the tissue. Often cercariae would swim or rest within a millimeter of

frog tissue without reacting toward it. However, when they swam into the frog or came to rest upon it, they immediately began to penetrate.

Cercariae were seen to penetrate adult *Rana pipiens, Rana aurora aurora,* and tadpoles of *Rana catesbiana* Shaw.

Hamsters experimentally fed free-swimming cercariae never harbored adult flukes.

The Metacercaria

Some and perhaps all cercariae that do not escape from the redia develop into metacercariae within it. The body was ovoid, flattened dorso-ventrally, and the surface was covered with small spines (Fig. 8). A few of the metacercariae retained a non-functional, shortened, feebly attached tail. Detached tails were often found free within a redia. The larvae, when removed from the redia and placed in 0.6% saline, were quite active, but did not progress readily across the bottom of a dish. Measurements were taken of metacercariae that were stained with Nile blue A. Body length varied from 0.18 mm. to 0.27 mm., width from 0.15 mm. to 0.21 mm.

The unarmed oral sucker opened terminally and measured from 0.45 mm. to 0.52 mm. in diameter. Six separate unicellular glands, each with a duct leading into the buccal cavity, lay side by side on the posterior rim of the oral sucker. These minute buccal glands were not present in the cercaria or in the adult. Their function is unknown. The pharynx was connected to the oral sucker by a short prepharynx. The average length of the pharynx was 0.038 mm.; the average width, 0.028 mm. The longitudinal axis of the pharynx usually lay in a diagonal position between the oral sucker and the intestinal ceca, to which it was connected by a long esophagus folded once upon itself. The two ceca extended laterally in the mid-region of the body, then turned posteriorly, passing laterally to the genital mass, the ventral sucker and the excretory bladder. They ended blindly on either side of the posterior excretory duct, 0.034 mm. from the end of the body.

The eyespots were dorsal, each located midway between the lateral body wall and the pharynx. The pigment granules making up an "eyespot" usually were in a compact mass, although there was sometimes dispersion of the granules in one or both eyespot loci. Rarely was there no trace of pigment.

The most characteristic and conspicuous feature of the metacercaria was the posterior, Y-shaped excretory bladder. It contained highly refractive bodies which appeared black by transmitted light. The stem and arms of the Y were about equal in length, the former ending at the posterior extremity of the body in an excretory pore. The main collecting ducts were arranged in a manner similar to that of the adult. There were, however, only 16 flame cells on each side of the metacercaria, two less than the number found in the mature fluke.

The ventral sucker and its associated gonotyl were on the right side of the body, just within the curvature of the right intestinal cecum. The sucker was broader than long, 0.031 mm. by 0.045 mm. The opening of the sucker was directed antero-medially and opened into the gonotyl, which had an irregular ventral opening.

The reproductive organs were well developed in the metacercaria. The ovary was situated in the fork of the excretory bladder. The uterus arose from the left side of the ovary, coiled and turned to the right, passing toward and opening into

the gonotyl. The elongate testes lay lateral to the arms of the Y-shaped excretory bladder, within the posterior extensions of the ceca. The testes averaged 0.031 mm. by 0.014 mm.

Metacercariae obtained from rediae survived only 30 minutes when they were placed in stream water. They lived 4 days when kept in 0.6% saline in the refrigerator at 7° C.

One sexually mature adult of *Metagonimoides* was recovered from the small intestine of a hamster 7 days after 20 metacercariae taken from rediae had been fed to this host. Heavy infections (50 to 60 flukes) were obtained by feeding hamsters the digestive gland of snails infected with approximately 1000 metacercariae.

Encysted metacercariae from cercariae experimentally introduced to the frog host were found principally in striated muscle tissue. In the early stages of development within the frog, metacercariae were frequently found in the kidney, but only in small numbers. Encysted forms taken from striated muscle of experimental as well as from wild frogs were morphologically identical with mature metacercariae that occur within a redia.

Two days after penetrating the frog, cercariae were found to be within thin, delicate, transparent cysts. They no longer possessed penetration glands, but were otherwise similar to the free-swimming forms. The cysts were 0.1 mm. in diameter. Twelve days after penetration, the encysted larvae possessed two intestinal ceca and a weakly developed ventral sucker. Finely granulated material was deposited around the original cyst wall and the cyst was slightly larger. Cysts after 30 days had marked depositions around the wall.

Forty-five days of development within the frog were necessary before the metacercariae reached the size and possessed the structures described in mature, infective metacercariae from a redia. The fully developed cyst was 0.21 mm. in diameter (Fig. 7).

Adult flukes were recovered from a hamster examined 7 days after having been fed metacercariae which had developed for 70 days in an experimentally-infected *Rana pipiens*. It is likely that less than 70 days is required for the metacercariae to become infective. A feeding of metacercariae 44 days in the frog did not produce adult flukes in the hamster, but only 12 cysts were available. Of over 50 cysts fed at 70 days, only 4 adult flukes were found in the small intestine. The infectivity in the hamster seemed low; probably it is not a good host for this parasite.

DISCUSSION

The observations made by Ingles (1935) on the larval stages of *Metagonimoides oregonensis* that occur in *Goniobasis nigrina* led him to draw conclusions concerning the life cycle of this form which are at variance with the observations contained in this report. Ingles could not find a birth pore on the redia, and no mention was made of finding free-swimming cercariae shed from the snail. Consequently, his description of the cercaria was made on forms which were present within a redia, and differs from the description as given here. Ingles' measurements of the cercaria were generally greater and no penetration glands or oral spines were reported. The cercaria he described possessed a mid-ventral acetabulum and two intestinal ceca, structures which are not yet developed in the free-swimming forms. We believe

that the "cercaria" of Ingles was an early intermediate stage of development toward the metacercaria within the redia.

The features that Ingles noted led him to conclude that the cercaria never experience a free-swimming existence. The present study gives ample evidence of a free-swimming cercarial stage, although such a stage is not obligatory in the cycle. A confirmation of Ingles' observations using *Goniobasis nigrina,* in the light of the present investigation, is needed. It is possible that he missed the free-swimming cercaria. The cycle herein described may, however, represent a transitional condition in the evolution of this fluke, in which the free-swimming cercarial stage is optional in *Goniobasis silicula* and lost in the cycle when the host is *Goniobasis nigrina.* Loss of the free-swimming cercarial stage has been reported in various trematodes by Sinitsin (1901, 1911) and Dobrovolny (1939). Life cycles in which the cercariae may either emerge from the redia or develop to metacercaria within it have been reported by Sinitsin (1911), McMullen (1937, 1938) and Cort and Brackett (1937).

It may be that there is a critical period in the development of the cercariae of *Metagonimoides oregonensis* during which the larvae are capable of emergence from the redia and of a free-swimming existence. If they do not emerge, they become metacercariae within the redia. The prevalence of the metacercariae within rediae is apparently correlated with the age of the redia. Metacercariae were generally more numerous in larger rediae, whereas developing and mature cercariae outnumbered the metacercariae in smaller, and presumably younger, rediae. This condition was apparent in both young and old snails infected with the larval stages of this parasite. The two snails which were found to contain no metacercariae were both small, but no smaller than many that harbored metacercariae. Presumably the rediae in these two snails were young.

Although the majority of heterophyid cercariae encyst in the skin of fish, frogs have been reported to serve as host for the metacercariae of flukes of the genus *Euryhelmis* by Zeller (1867), Joyeux, Baer and Carrère (1934), and Ameel (1938).

The metacercariae of *Metagonimoides oregonensis,* whether in the snail or in the frog, are equally infective to the definitive host. Both intermediate hosts are known to be represented in the diet of the racoon.

SUMMARY

The major stages involved in the life history of *Metagonimoides oregonensis,* a heterophyid trematode of the racoon, were identified and described. The life cycle was completed experimentally from the cercaria to the adult.

Eggs contained miracidia after 23 days of incubation in water. Hatching was not observed.

Rediae occurred in the digestive gland of the snail, *Goniobasis silicula* (Gould). They contained pleurolophocercous cercariae, infective metacercariae and intermediate stages between the two, but never daughter rediae.

Cercariae were produced in the redia and either emerged from it or developed directly into unencysted metacercariae within the redia. When these metacercariae were fed to hamsters they developed to sexually mature flukes in 7 days in the intestine of that host. Cercariae that emerged from the rediae penetrated the skin

of frogs and tadpoles, and encysted in striated muscle. Cercariae penetrated adults of *Rana pipiens, Rana aurora aurora,* and the tadpole of *Rana catesbiana.*

Metacercariae, 45 days after penetrating a frog, were morphologically identical with infective metacercariae developed within rediae. Metacercariae from the frog were infective 70 days following cercarial penetration. These developed to adult flukes within 7 days in the hamster. Encysted metacercariae occurred naturally in *Rana aurora aurora.*

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Plate I

Fig. 1. The excretory system of the adult fluke, *Metagonimoides oregonensis.* Col D Collecting duct, Ex B Excretory bladder, F C Flame cell, Gt Gonotyl, Int C Intestinal cecum, O S Oral sucker, Ov Ovary, Ph Pharynx, S R Seminal receptacle, T Testis, V S Ventral sucker.

Fig. 2. Newly passed egg of *Metagonimoides oregonensis.* Ov Ovum, Vit C Vitelline cell.

Fig. 3. Embryonated egg containing motile miracidium.

Fig. 4. Mature redia containing cercariae and metacercariae. B P Birth pore, C Cercaria, Int Intestine, M Metacercaria, Ph Pharynx.

Plate II

Fig. 5. Pleurolophocercous cercaria of *Metagonimoides oregonensis* after emergence from the snail *Goniobasis silicula.* Eye Eyespot, Ex B Excretory bladder, F F Fin fold, O S Oral sucker, P G Penetration gland.

Fig. 6. Body of cercaria. Eye Eyespot, Ex B Excretory bladder, G A Genital anlagen, O S Oral sucker, P G Penetration gland, P G D Penetration gland duct, Ph Pharynx.

Fig. 7. Infective metacercaria of *Metagonimoides oregonensis* taken from the striated muscle of a frog. C W Cyst wall, Eye Eyespot, Ex B Excretory bladder, O S Oral sucker, Ph Pharynx, V S Ventral sucker.

Fig. 8. Infective metacercaria taken from a redia. B G Buccal glands, Col D Collecting duct, Eso Esophagus, Eye Eyespot, Ex B Excretory bladder, Ex P Excretory pore, F C Flame cell, Gt Gonotyl, Int C Intestinal cecum, O S Oral sucker, Ov Ovary, P Ph Prepharynx, Ph Pharynx, Sp Spines, T Testis, Ut Uterus, V S Ventral sucker.

PLATE I

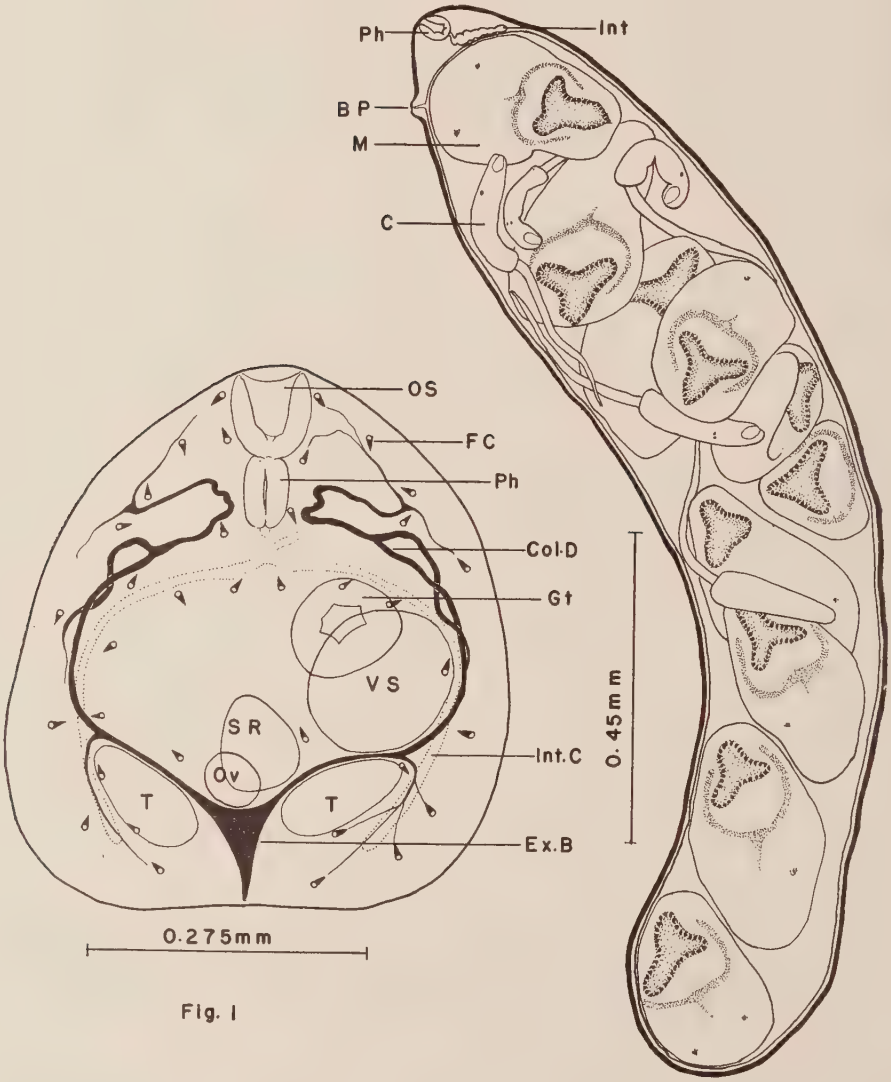

Fig. 1

Fig. 4

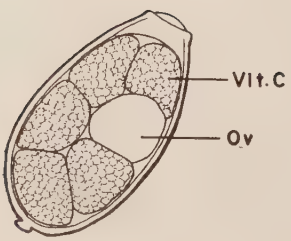

Fig. 2

0.03mm

Fig. 3

PLATE II

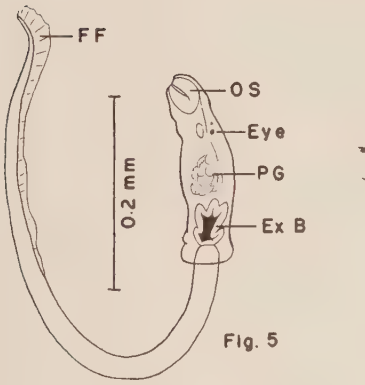

Fig. 5

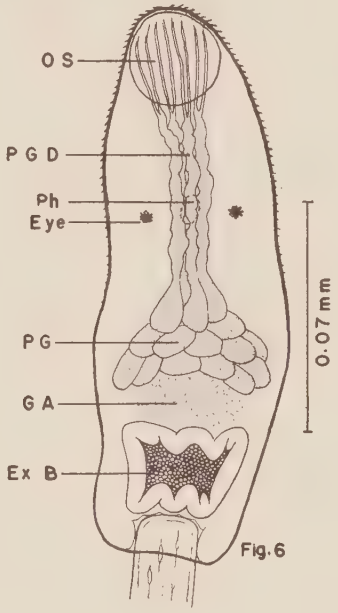

Fig. 6

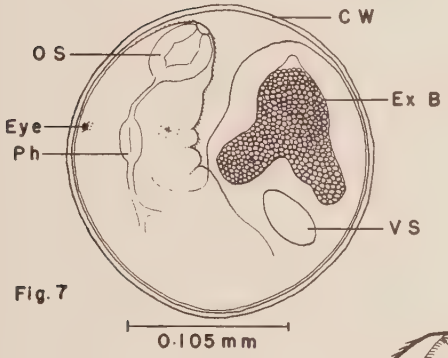

Fig. 7

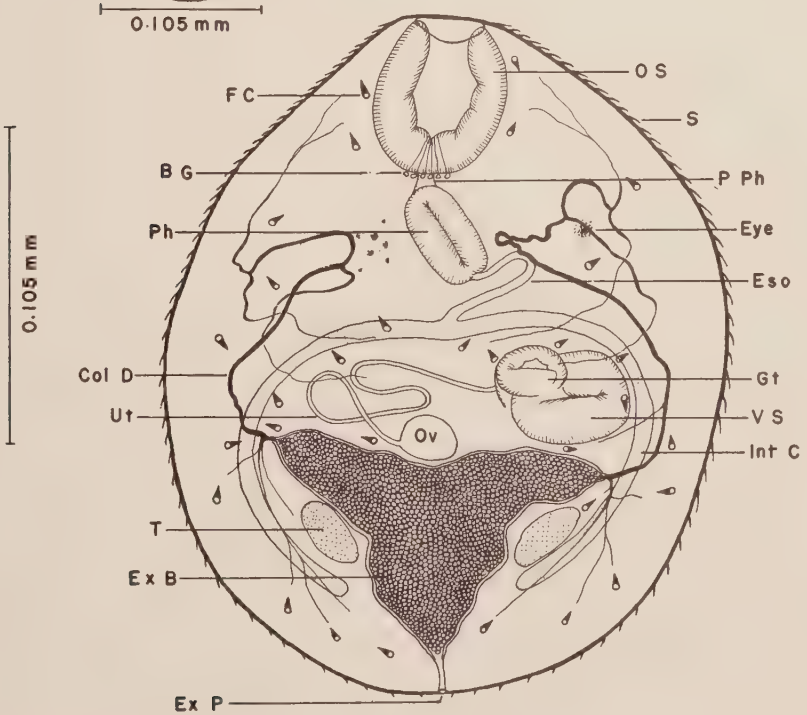

Fig. 8

MITES OF THE GENERA *MYIALGES* AND *MICROLICHUS* (ACARINA: EPIDERMOPTIDAE) FROM AVIAN AND INSECT HOSTS[1]

DEANE P. FURMAN AND I. BARRY TARSHIS[2]

Mites of the genera *Myialges* and *Microlichus* are of particular interest in that they are commonly found as hyperparasites upon parasitic insects such as hippoboscid flies and mallophagans as well as in some instances upon the avian hosts of these parasites. Cooreman (1944) summarized much of the information on species of these genera, designating insect and avian hosts as well as recorded geographic distribution.

Very little is known of the life cycle of the mites. The male is described for only two species, *Microlichus avus* (Trouessart, 1887), and *Myialges trinotoni* (Cooreman), and there is a question as to whether the former is actually conspecific with the female *M. avus* since it was collected from a different host and apparently in the absence of female mites (Trouessart and Neumann, 1888). Radford (1949) described the male of *M. trinotoni* from a series of mites previously identified as *Myialges caulotoon* Speiser by Vitzthum.

Most of the specimens examined in this study were collected over a four-year period from 1948 to 1951 in conjunction with a project on quail malaria which entailed collection of hippoboscid flies from birds in the wild state.

A total of 2,189 hippoboscid flies was obtained from 2,430 California Valley Quail, *Lophortyx californica vallicola* (Ridgway), trapped in eight counties (Napa, Contra Costa, Alameda, Santa Cruz, Monterey, San Benito, San Luis Obispo and Kern) in California. Of these 58.9 per cent were *Stilbometopa impressa* (Bigot) and 41.1 per cent were *Lynchia hirsuta* Ferris.

The collections were made from June through November, but the peak months for flies appear to be August, September and October. In one study area, Chiles Valley (Napa County), where collection records were available on an annual basis, there was a complete absence of both species of flies from January to May. In this area the first specimens of *Lynchia hirsuta* were taken during the first week of June and specimens of *Stilbometopa impressa* were first obtained during the second week of July. *Lynchia hirsuta* were also taken during the middle of June at the San Pablo Dam area (Contra Costa County). Although exact data are not available from the other study areas for the winter and spring months, trappers have reported seeing quail flies as early as April in Monterey Co., San Benito Co., and San Luis Obispo Co. Species of flies were not noted.

Of the two species of flies collected only *Lynchia hirsuta* was found parasitized by mites, although both species of flies were found living on the same individual bird.

Of the 900 specimens of *L. hirsuta* taken from trapped quail, 20 (2.2 per cent) were found parasitized with mites. Eighteen of the infested flies harbored *Myialges anchora* Sergent and Trouessart, and two flies were found to harbor a new species

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of *Microlichus* Trouessart and Neumann. Twelve of the parasitized flies were taken at Bitterwater, San Benito County, seven at the Hunter Liggett Military Reservation, Monterey Co., and one at San Pablo Dam, Contra Costa Co. Parasitized flies were taken during the months of June, August, September, October and November.

Myialges anchora was also taken from four *Lynchia fusca* specimens collected from a "Great Horned Owl" (*Bubo virginianus*) collected October 21, 1950 at Ripon, San Joaquin Co., California by O. Burneti.

The cooperation of the California Department of Fish and Game, Bureau of Game Conservation, made possible the above collections of quail ectoparasites.

Additional specimens of mites of the genera *Myialges, Myialgopsis* and *Microlichus* were obtained from the following sources for comparative study: U. S. National Museum, Dr. G. F. Ferris, Dr. J. Bequaert, and Dr. C. Herman. The authors express their appreciation to Drs. J. Bequaert and E. W. Baker for their interest and constructive comments, and to Mrs. Bernice Tarshis for making final drafts of illustrations.

The mites collected during the current survey were mounted in C-M medium described by Clark and Morishita (1950). This mounting medium has been found highly satisfactory in preparing permanent mounts of most species of parasitic mites. It not only provides a very rapid means of mounting mites but it has a refractive index of 1.428, excellent for this type of preparation. Even the phase contrast microscope, which was used for the study of all specimens mounted in media other than the C-M preparation, failed to resolve structures as clearly as standard microscopy with the C-M mounting medium.

Family Epidermoptidae Trouessart, 1892

Epidermopteae Trouessart, 1892, Rev. Sci. Nat. Ouest. **2**: 50; Canestrini, 1894, Prosp. Acarof. **6**: 817; Canestrini, G. and P. Kramer, 1899, Demodicidae und Sarcoptidae (Berlin): 128–9.

Avenzoariidae Oudemans 1908, in part; Vitzthum, 1929, Die Tierwelt Mitteleuropas **3** (5): 97.

Epidermoptidae Trouessart, 1892; Vitzthum, 1929, Die Tierwelt Mitteleuropas **3**: 102; 1934, Bull. Mus. roy. Hist. Nat. Belg. **10**: 13; 1941–3 Bronn's Klassen und Ordnungen des Tierreichs, "Acarina," **5**: 897.

Myialgesidae Trouessart, 1907, Bull. Soc. Zool. France, **31**: 128 (new synonym).

Trouessart (1907) established the subfamily Myialgesinae of the Sarcoptidae on the basis of host affinities; the only described species, *Myialges anchora*, was taken from a "cold-blooded host," a hippoboscid fly. Since hippoboscids are essentially homiothermic in that they spend their entire lives in close proximity to the skin of homiothermic hosts, this is hardly a distinction. Furthermore, members of the family Epidermoptidae in the genus *Microlichus* have been taken from hippoboscids as well as from birds. Morphologically there is no good constant difference on which the families Epidermoptidae and Myialgesidae can be distinguished. The length of pedicels on tarsal caruncles varies in the different genera, the apodemes of coxae I may lie free or be fused, varying between the species of a single genus (e.g. *Microlichus uncus* Vitz. and *Microlichus lophortyx* n. sp.). The anal opening shows gradation in position from a terminal ventral location to a wholly

terminal position with the anal groove extending from dorsum to venter (e.g. *Dermatophagoides scheremetewskyi* Bogdenow and *Microlichus uncus* Vitzthum).

The following diagnosis of EPIDERMOPTIDAE represents a modification of that given by Baker and Wharton (1952): Usually on the skin of birds or on their ectoparasites, some from mammals. Very small mites measuring from 0.17 to 0.39 mm. in length. Body rather flat, usually very short and rounded. Propodosomal shield and in some a hysterosomal shield present. No vertical setae on the propodosoma. Skin soft and striated. The posterior of the male often notched or bilobate while that of female is usually rounded. The male possesses copulatory suckers. All tarsi with caruncles (with the possible exception of *Myialges caulotoon* Speiser where caruncles have not been demonstrated on first tarsi).

KEY TO GENERA OF EPIDERMOPTIDAE

1. Tarsal claws or claw-like spines on all legs 2
   Tarsal claws absent on some legs or vestigial 4
2. Apodemes of coxae I not fused; tarsal claws single; transverse propodosomal groove present *Epidermoptes* Rivolta, 1876
   Apodemes of coxae I fused; tarsal claws double; propodosomal groove absent 3
3. Vulva longitudinal; female without copulatory cones; a whip-like seta on each tarsus; ambulacra of male similar to those of female ..... *Pneumocoptes* Baker, 1951
   Vulva transverse; female with a pair of copulatory cones at posterior end of body; no whip-like setae on tarsi; ambulacra of male rudimentary ..... *Turbinoptes* Boyd, 1949
4. Tarsal claws absent or vestigial 5
   Tarsal claws prominent though variously modified on 1st tarsi 7
5. Femora III and IV of female with reflex, hook-like apophyses *Dermation* Trouessart and Neumann, 1888
   Femora of female without reflex, hook-like apophyses 6
6. Posterior end of body not lobed in either sex; no long setae on tarsi III and IV; live on mammals ..... *Dermatophagoides* Bogdenow, 1864
   Posterior end of body divided into two widely separated lobes in male; long setae on tarsi III and IV; live on skin of birds ..... *Rivoltasia* G. Canestrini, 1894
7. Hysterosomal plate present; claw present on tarsus II of female *Microlichus* Trouessart and Neumann, 1888
   Hysterosomal plate absent; claw absent on tarsus II of female *Myialges* Sergent and Trouessart, 1907

Microlichus lophortyx N. SP.

Idiosome of type female 316 μ long and 216 μ wide, shape broadly oval.

Dorsum.—(Fig. 1) Line between propodosoma and hysterosoma indefinite to absent. Propodosomal plate irregularly pentagonal. Four platelets overlying bases of legs II and III. Hysterosomal plate U-shaped with open end directed posteriorly, 150 μ long; an irregular longitudinal line on posterior ¾ of each lobe. Margins of plate vary between specimens, particularly in depth of the cleft between the two lobes. Dorsal plates finely granular with ill-defined borders; surrounding cuticula finely striated. All body setae smooth. Two pairs of slender scapular setae on cuticula bounding postero-lateral angles of propodosomal plate, the longer but equally fine outer pair 43 μ in length (approximately 2/3 the length of the propodosomal plate). Internal humeral seta on anterior margin of plate over leg III approximately ½ length of leg. External humeral seta laterally situated, longer than leg. Two pairs fine setae on lateral margins of hysterosomal plate, the posterior pair 60 μ long, about twice as long as anterior pair. Two similar pairs of fine setae between anal orifice and hysterosomal plate. Two pairs of very long setae on small posteriorly placed tubercles; setae of equal strength but outer pair longer, measuring 286 μ long. Oil glands near lateral margins of opisthosoma visible on paratype. Anal groove terminal, extending dorso-ventrally.

Venter.—(Fig. 2) Apodemes of coxae I converge at level approximately 2/3 of distance from anterior ends, diverging posteriorly, fused internally for about 1/5 of their length; the posterior diverging arms similarly fused with endogynium. Apodemes of coxae II well developed, free, extending almost to arm of endogynium. Apodemes of coxae III and IV shorter, appearing to be joined internally but not on surface. Endogynium in form of a half circle, with arms extending well posterior to 2nd coxal apodemes, with two small, tooth-like, postero-median

projections. Genital lobes arranged in an inverse V-shape immediately behind endogynium; very lightly sclerotized. A moderately long seta on coxae I and III; three similar pairs placed latero-medially near the anterior and posterior ends of the genital lobes, and just posterior to the metapodosoma. A row of 4 moderately long setae flank the anterior end of the anal groove.

Mouthparts.—(Fig. 3) Ventrally a pair of setae on the basal plate of maxillae; palp with segmentation obscure, a lateral seta on basal segment. Chelicerae with fixed and movable arms bearing small blunt teeth. A pair of transparent ventral lobes arising from maxillary base cover most of mouthparts as illustrated.

Legs.—Short, stout; legs increase in length from anterior to posterior pairs. Leg I about 1½ times as thick as II and twice as thick as legs III and IV. All legs with coxa, trochanter, femur, genu, tibia and tarsus. Leg I (Fig. 4) with a strong tarsal claw attached to a very small tarsal segment. Leg II with a similar though very small tarsal claw. Legs III and IV lacking tarsal claw. All tarsi with caruncle borne on a short pedicel; caruncle entire, subglobular, with terminal, short, sharp tip. Legs with setae as illustrated. Tarsi III and IV with a very long seta (198 μ) in addition to shorter setae.

Types.—Described from 3 females collected from *Lynchia hirsuta* Ferris taken on *Lophortyx californica vallicola* (Ridgway) at Bitterwater, San Benito Co., California. Collected August 29, 1949 by I. B. Tarshis. Holotype female deposited with the U. S. National Museum. Paratypes in collection of D. P. Furman.

The specimens were collected from the ventral inner surface of the wings of *Lynchia hirsuta,* where they were attached to a wing vein. Eggs surrounding them appeared to be attached singly by a very short stalk to a membranous substrate, closely adherent to the wing membranes. The eggs are elongate oval bodies measuring 176 μ long by 80 μ wide.

Microlichus lophortyx is closely related to *Microlichus uncus* Vitzthum (1934) from which it may be distinguished by the fused apodemes of coxae I, the short outer scapular pair of setae, and the elongated arc of the endogynium which extends well posterior to the apodemes of coxae II. It also differs in possessing an undivided hysterosomal plate, but variations in the plate shape lead one to wonder if specimens may be found with a completely divided hysterosomal plate. *M. lophortyx* may be differentiated from *Microlichus avus* (Trouessart 1887) in that the endogynial arc of the latter has no median tooth-like projections, and is short, not extending to the level of the inner ends of the apodemes of coxae II; of the two pairs of postero-dorsal body setae the outer pair are much stouter and longer than the inner on *M. avus.*

Microlichus perdicis Canestrini (1894) has only 2 long setae on the postero-dorsal margin of the body and has a more elongate body than *M. lophortyx.*

Key to Females of *Microlichus*

1. Hysterosoma with only 2 long, posterior, marginal setae; endogynium with 2 median tooth-like structures ..... *Microlichus perdicis* Canestrini
   Hysterosoma with 4 long, posterior marginal setae; endogynium with or without tooth-like structures 2
2. Claws of tarsi I and II subequal; outer posterior, marginal setae much stronger than inner pair ..... *Microlichus avus* (Trouessart)
   Claw of tarsus I much stronger than that of tarsus II; outer, posterior marginal setae subequal in strength to inner pair. 3
3. Apodemes of coxae I fused; outer scapular setae delicate, 2/3 as long as propodosomal plate ..... *Microlichus lophortyx* n. sp.
   Apodemes of coxae I not fused; outer scapular setae strong, approximately twice as long as propodosomal plate ..... *Microlichus uncus* Vitzthum

Myialges

Myialges Sergent and Trouessart, 1907, C. R. Soc. Biol. **62**: 444; Trouessart, 1907, Bull. Soc. Zool. France **31**: 128; Speiser, 1907, Sjöstedts Kilimandjaro-Meru

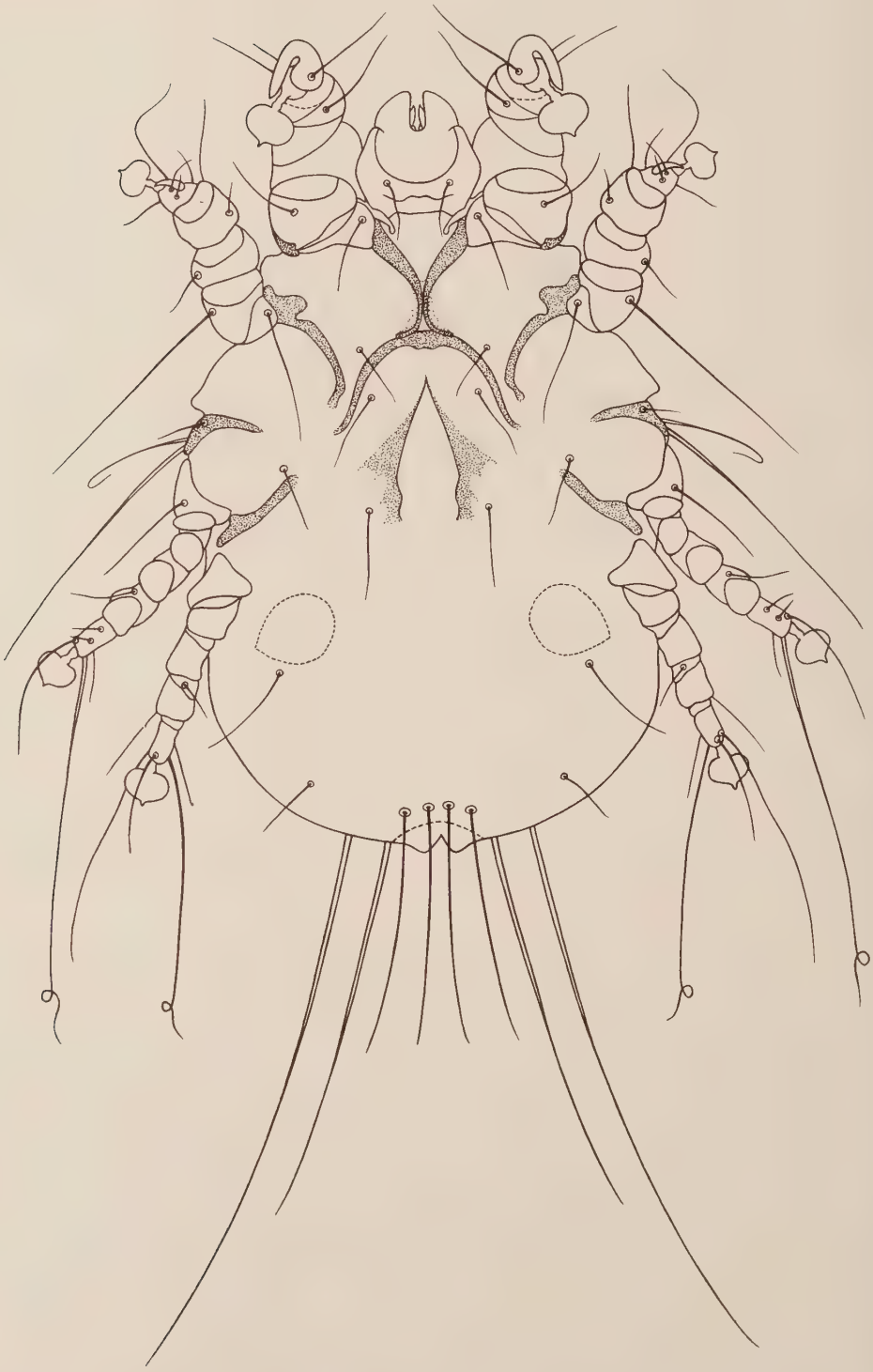

FIG. 1. *Microlichus lophortyx* sp. nov. Ventral view.

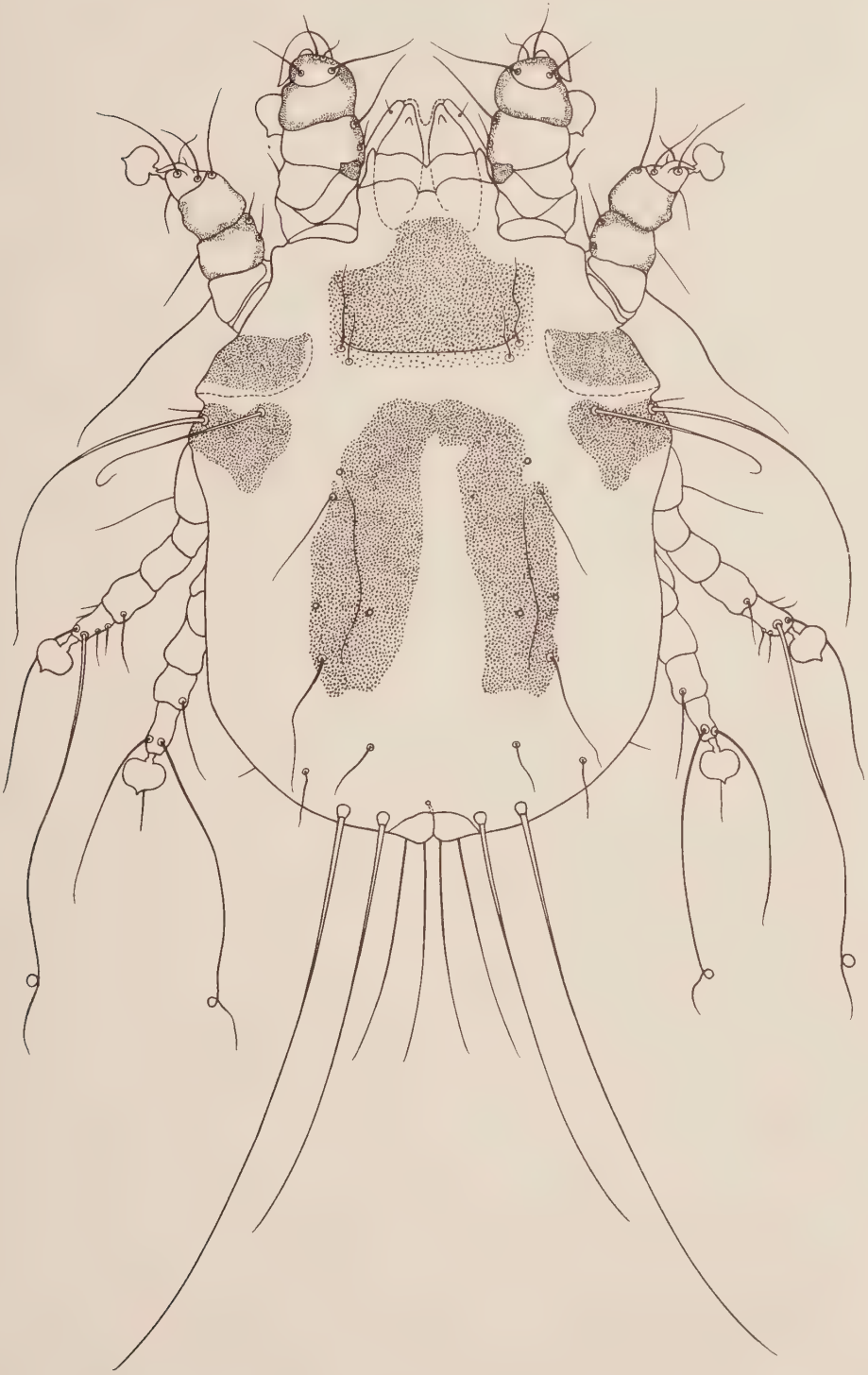

FIG. 2. *Microlichus lophortyx* sp. nov. Dorsal view.

Exped. (Uppsala) Part 10: 9–10; Ferris, 1928, Ent. News, **39**: 137; Vitzthum, 1934, Bull. Mus. roy. Hist. nat. Belg. **10**: 12–17; Oudemans, 1935, Ann. Parasit. **13**: 5–11; Vitzthum, 1943, Bronn's Klassen und Ordnungen des Tierreichs **5** pt. **5**: 890.

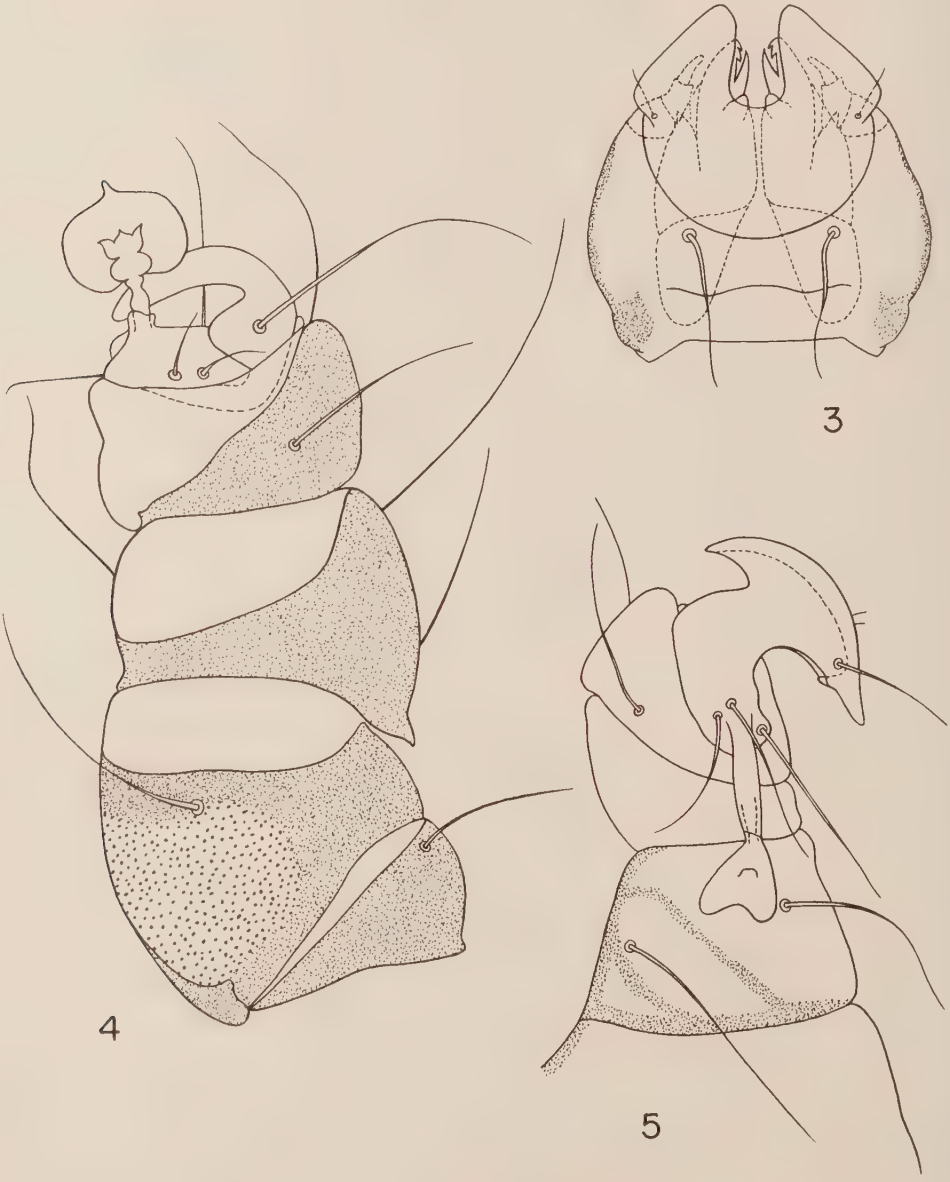

Fig. 3. *Microlichus lophortyx* sp. nov. Gnathosoma, ventral view.
Fig. 4. *Ibid.* Ventral view of left leg I.
Fig. 5. *Myialges anchora* Sergent and Trouessart. Ventral view of right leg I.

Myialgopsis Cooreman 1944 (new synonym).

The primary morphological characteristic upon which Cooreman established the monotypical genus *Myialgopsis* as distinct from *Myialges* was the presence of a

well-developed caruncle on tarsus I of the female of *Myialgopsis trinotoni* Cooreman; this structure has been declared absent on the two described species of *Myialges,* namely *M. anchora* and *M. caulotoon* Speiser (1907). Vitzthum (1934), however, pointed out the difficulties of recognizing the segmentation of leg I in *Microlichus uncus,* and particularly of differentiating the caruncle of leg I, which remains hidden under the tarsal tip; based on similarities between this species and *M. anchora* he postulated that there might exist a similar structure in the latter species which had been overlooked. That he was correct in his hypothesis is demonstrated here.

In a series of *M. anchora* collected from *Lynchia hirsuta* from *Lophortyx californica vallicola* in California there is clearly evident a well-developed caruncle on tarsus I (see fig. 5). The structure is also distinct on tarsus I of *M. anchora* specimens from *Pseudolynchia canariensis* taken on domestic pigeon at Aba, Belgian Congo, and from *Lynchia fusca* taken on *Bubo virginianus* in California. The caruncle is not clearly visible in some specimens because of the orientation of the legs. Normally the pedicel of the caruncle is directed posteriorly along the axis of the leg and is thus easily overlooked. A further factor masking the presence of the caruncle on tarsus I appears to be inherent in certain mounting media used, since in old specimens mounted in media such as balsam the caruncle is usually impossible to see. However, in examining such a series under the phase contrast microscope the base of the pedicel was visible in a few specimens, and almost the entire caruncle was evident in one specimen from the collection of G. F. Ferris.

The undivided, bell-shaped appearance of the caruncle of *M. trinotoni* has also been cited as a characteristic of generic rank. The shape of the caruncle of *M. anchora* and *M. caulotoon* appears variable,depending on the degree of expansion of the structure, and may thus be seen to range from a small compact structure with the suggestion of a trilobate extremity to a definitely bilobed condition, the "cloven hoof" of Oudemans (1935). This character is not considered of generic rank.

The distinction between *Microlichus* Trouess. and Neum. and *Myialges* Serg. and Trouess. is believed to be valid. However, the basis of differentiation is changed as a result of the findings recorded here. Neither the presence of the caruncle on leg I nor the fusion of the apodemes of coxae I may be used to differentiate these genera. At least two described species of *Myialges* possess a caruncle on leg I and there is reason to believe such a structure may be present on the remaining species, *M. caulotoon.* Previously described species of *Microlichus* have the apodemes of coxae I ending freely, whereas in *Myialges* the apodemes are fused. In the new species, *Microlichus lophortyx*, there is an intermediate condition, where the closely approximated apodemes of coxae I form two ridges fused by a less heavily chitinized substructure. The genera are separable in that there is no hysterosomal plate in *Myialges* whereas there is in *Microlichus* (condition of dorsum inadequately described for *Microlichus perdicis* Canestrini, 1894). *Microlichus* females possess a claw on tarsus II which is absent in *Myialges* females.

Key to Females of *Myialges*

1. Claw of tarsus I with only one arm, not anchor shaped; apodeme of coxa I fused with that of coxa II ..... *Myialges caulotoon* Speiser

Claw of tarsus I with two arms, anchor shaped; apodeme of coxa I not fused with that of coxa II 2

2. Tibia II with sharp, reflexed apophysis; caruncles bilobed
Myialges anchora Serg. and Trouess.

Tibia II without apophysis; caruncles entire, bellshaped .. *Myialges trinotoni* (Cooreman)

Figueredo and Barbosa (1944) described and figured *Myialges pseudolynchiae* as a new species from *Pseudolynchia canariensis* (= *maura*) on the domestic pigeon in Brazil. The figures and description are inadequate, but in all probability the species is a synonym of *Myialges anchora* Sergent and Trouessart.

SUMMARY

A new species of mite, *Microlichus lophortyx,* based on females, is described from quail flies, *Lynchia hirsuta,* taken at Bitterwater, California. Keys to genera of EPIDERMOPTIDAE, and to the females of *Microlichus* and *Myialges* are provided. New synonymy includes: MYIALGESIDAE, Trouessart equals EPIDERMOPTIDAE Trouessart, and *Myialgopsis* Cooreman equals *Myialges* Sergent and Trouessart.

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THE TAENIACIDAL ACTIVITY OF SEVEN HALOGENATED DIPHENYL METHANES, A DIPHENYL PROPANE AND A DIPHENYL ETHER

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INTRODUCTION

Recent studies have revealed the taeniacidal action of certain diphenyl methanes (or chlorinated bis-phenols). Craige and Kleckner (1946) reported that Diphenthane-70 (2,2′-dihydroxy-5,5′-dichlorodiphenyl methane) was active in removing *Taenia pisiformis* and *Dipylidium caninum* from dogs. A subsequent publication, Burch and Blair (1950), indicated that Diphenthane-70 is also effective against tapeworms in cats. These authors failed to identify the species of cestode with which they were working. Diphenthane-70 has also been used to treat cestode infections of sheep. Ryff, Honess and Stoddard (1949) and Ryff et al. (1950) reported that the compound is effective in removing *Moniezia sp.* and the fringed tapeworm, *Thysanosoma actinioides*, from sheep. Kerr (1948) reported that hexachlorophene (2,2′-dihydroxy-3,3′,5,5′,6,6′-hexachlorodiphenyl methane) is effective in removing *Raillietina cesticillus* from chickens.

During the work in which the activity of hexachlorophene against *R. cesticillus* was determined, an opportunity arose to test certain related compounds. The results of testing these compounds for anthelmintic activity against *R. cesticillus* are presented in this paper.

MATERIALS AND METHODS

The procedure used for determining the taeniacidal activity of a substance was based on the one described by Moskey and Harwood (1941) and called by them the controlled test. This procedure requires the laboratory infection of birds so that a comparison may be made between the number of worms remaining in medicated and nonmedicated groups at a definite time, usually two weeks, following the administration of medication. All of the chickens used were New Hampshires supplied to us by the research farm of Dr. Salsbury's Laboratories.

All the chickens in a test were infected by giving each bird a capsule containing a known number of infected beetles, *Tribolium confusum*, from the same culture. The number of beetles given per bird in the several infections varied according to the degree of infection with cysticercoids. Forty beetles from each culture were dissected, the cysticercoids counted and the average infection per beetle was calculated. Whenever possible a calculated total of 75 cysticercoids was given to each bird. Kerr (1949) has indicated that this method of infection is more satisfactory than using cysticercoids dissected free from the intermediate host. The method definitely produces a greater number of heavily infected birds (50 or more tapeworms per bird) and we believe that the heavier infections provide a more severe test of anthelmintic activity.

The test birds were individually caged three to four days previous to medication so that they were well accustomed to their quarters by the time the test was started.

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During this period infection in each bird was proved by finding proglottids in the droppings. All noninfected birds were discarded.

The medication was given as a single oral dose by capsule on the basis of either mgm. per kgm. body weight or mgm. per bird. The mgm. per kgm. body weight dosages were calculated to the nearest five mgm. of drug. The medication was administered after the birds had been without food for approximately 16 hours. Food was made available to the birds immediately following medication. Water was before the birds at all times.

All of the birds were weighed on the day of medication and when they were killed. No attempt was made to balance the groups as to weight, but all of the birds used in a test were of the same age and general condition and an approximately equal number of males and females were used per group.

An interval of two weeks elapsed between medication and the killing of the chickens. This interval permits considerable regrowth of any strobila which may have been desegmented as a result of the medication and thus facilitates the counting of the tapeworms which remain in the birds. When the birds were killed the total number of worms remaining in each group was determined and the average number of worms per bird was calculated. The indicated efficacy in terms of per cent removal was determined by comparing the average number of worms left in the treated and untreated control groups.

RESULTS

Seven compounds of the diphenyl methane series, one diphenyl propane and one diphenyl ether were tested. The summarized results of the tests are presented in Table 1. It is recognized that the factual data reported in this table are derived mostly from small groups of birds, frequently only four in number. For this reason in discussing the results, no emphasis is given to the actual figures obtained. In our opinion it is more important to point out the trends which these data may indicate relative to possible chemical relationships and biological activity.

Only two of the compounds tested, 2,2′-dihydroxy-3,3′,5,5′,6,6′-hexachlorodiphenyl methane (IV) and 2,2′-dihydroxy-3,3′,4,4′,5,5′,6,6′-octachlorodiphenyl ether (V), may be considered as possessing a high degree of activity against *Raillietina cesticillus*. The former compound is the more active because a lower dosage (50 mgm./kgm.) is required to produce the same degree of activity as found with a higher dosage (100 mgm./kgm.) of the latter compound.

In Table 2 the data presented in Table 1 has been summarized for the purpose of making broad comparisons between the types of compounds represented. In comparing the three compounds, 2,2′-dihydroxy-5,5′-dichlorodiphenyl methane (Diphenthane-70, G-4), 2,2′-dihydroxy-3,3′,5,5′-tetrachlorodiphenyl methane (G-5) and 2.2′-dihydroxy-3,3′,5,5′,6,6′-hexachlorodiphenyl methane (Hexachlorophene, G-11), Compounds I, II and IV in Tables 1 and 2, it will be noted that the degree of anthelmintic activity seems to be related to the number of chlorine atoms each compound contains. As the number of chlorine atoms increases from two through four to six the taeniacidal activity increases.

These data do not cover a broad enough group of compounds to determine whether the hydroxyl group is essential to activity. The one compound tested which is not a phenol, Compound III, appears to possess about the same degree of activity as

TABLE 1.—*Summary of tests to determine anthelmintic activity against* Raillietina cesticillus

No.	Compound Name	Dosage Mgm./kgm.	Dosage Mgm./bird	No. infected birds	Total no. *Raillietina cesticillus* at necropsy	Av. no. *Raillietina cesticillus* per bird	Indicated efficacy (per cent)
I	2,2′-Dihydroxy-5,5′-dichlorodiphenyl methane (Diphenthane-70, G-4)	50	..	8	193	24.1	5
		100	..	8	159	19.9	22
		150	..	8	148	18.5	27
		200	..	8	198	24.7	3
		Unmedicated controls		8	203	25.4	..
		..	725	2	17	8.5	42
		Unmedicated controls		6	88	14.67	..
II	2,2′-Dihydroxy-3,3′,5,5′-tetrachlorodiphenyl methane (G-5)	100	..	4	21	5.25	46
		200	..	4	26	6.5	33
		300	..	4	58	14.5	0
		400	..	4	18	4.5	54
		Unmedicated controls		4	39	9.75	..
III	3.3′,4,4′-Tetrachlorodiphenyl methane	100	..	4	120	30	23
		200	..	4	123	30.75	21
		300	..	4	231	57.75	0
		400	..	4	73	18.25	53
		Unmedicated controls		8	310	38.75	..
IV	2,2′-Dihydroxy-3,3′,5,5′,-6,6′-hexachlorodiphenyl methane (Hexachlorophene, G-11)	..	70	11	1	0.09	98
		Unmedicated controls		4	23	5.75	..
		..	50	4	14	3.5	56
		Unmedcated controls		4	32	8.0	..
		..	50	15	6	0.4	92
		Unmedicated controls		5	26	5.2	..
		..	50	27	10	0.37	98
		Unmedicated controls		9	228	25.33	..
		..	50	18	11	0.61	97
		..	100	9	2	0.22	99
		Unmedicated controls		9	176	19.56	..
V	2,2′-Dihydroxy-3,3′,4,4′,-5,5′,6,6′-octachlorodiphenyl ether	100	..	5	12	2.4	87
		150	..	5	7	1.4	92
		200	..	6	9	1.5	92
		Unmedicated controls		5	91	18.2	..
		300	..	6	3	0.5	96
		400	..	6	0	0	100
		Unmedicated controls		6	84	14	..
		100	..	4	37	9.25	5
		200	..	4	1	0.25	97
		300	..	4	0	0	100
		Unmedicated controls		4	39	9.75	..
VI	3,3′-Dihydroxy-2,2′,4,4′,-5,5′,6,6′-octachlorodiphenyl propane (bis (tetrachloro-3-hydroxyphenyl) propane)	25	..	4	128	32	16
		50	..	4	156	39	0
		100	..	4	127	31.75	16
		200	..	4	121	30.25	20
		Unmedicated controls		4	152	38	..
VII	4,4′-Dihydroxy-3,3′,5.5′,-6,6′-hexachlorodiphenyl methane	25	..	4	73	18.25	7
		50	..	4	122	30.5	0
		75	..	4	66	16.5	16
		Unmedicated controls		9	176	19.56	..
		100	..	4	100	25	0
		Unmedicated controls		9	228	25.3	..
VIII	4,4′-Dihydroxy-3,3′,5,5′,-6,6′-hexabromodiphenyl methane	200	..	1	9	9	0
		300	..	4	47	11.75	0
		400	..	3	20	6.67	32
		Unmedicated controls		4	39	9.75	..
IX	4,4′-Dihydroxy-3,3′,5,5′-tetrabromodiphenyl methane	50	..	4	100	25.00	32
		100	..	4	19	4.75	87
		200	..	4	107	26.75	27
		300	..	4	66	16.5	55
		Unmedicated controls		3	110	36.67	..
		200	..	3	40	13.33	52
		300	..	4	55	13.75	50
		400	..	4	22	5.5	80
		500	..	3	39	13.0	53
		Unmedicated controls		6	165	27.5	..
		100	..	4	24	6	38
		400	..	4	8	2	79
		Unmedicated controls		4	39	9.75	..

Compound II. Thus, in this instance, the phenolic group does not seem to be essential.

From the limited data available, it appears that the position of the hydroxyl group

may be of importance in the activity of the compounds. Compound No. VI, 3,3′-dihydroxy-2,2′,4,4′,5,5′,6,6′-octachlorodiphenyl propane, is relatively inactive and Compound VII, 4,4′-dihydroxy-3,3′,5,5′,6,6′-hexachlorodiphenyl methane, was completely inactive at the dosages used. The latter compound differs only from the highly active compound, hexachlorophene (Compound IV), in the position of the hydroxyl group. An exception to this is found for Compound IX, 4,4′-dihydroxy-3,3′,5,5′-tetrabromodiphenyl methane. This compound apparently is quite active and the data indicate that it is more active than 2,2′-dihydroxy-3,3′,5,5′-tetrachlorodiphenyl methane (Compound II).

No valid conclusion can be drawn with regard to the effect of the type of halogen atom involved for only two brominated compounds were tested, and in neither of these were the hydroxyl groups in the same position as found in the highly active chlorinated compounds. Whether the indication that bromination makes the com-

TABLE 2.—*Summarization of the data with respect to the position of the various atoms and chemical groups on the molecules*

No	Compound Name	Atom position 2	3	4	5	6	X	Degree of activity (per cent)
I	2,2′-Dihydroxy-5,5′-dichlorodiphenyl methane	OH	..	..	Cl	..	CH_2	0–25
II	2,2′-Dihydroxy-3,3′,5,5′-tetrachlorodiphenyl methane	OH	Cl	..	Cl	..	CH_2	25–50
III	3,3′,4,4′-Tetrachlorodiphenyl methane	..	Cl	Cl	..	..	CH_2	25–50
IV	2,2′-Dihydroxy-3,3′,5,5′,6,6′-hexachlorodiphenyl methane	OH	Cl	..	Cl	Cl	CH_2	75–100
V	2,2′-Dihydroxy-3,3′,4,4′,5,5′,6,6′-octachlorodiphenyl ether	OH	Cl	Cl	Cl	Cl	O	75–100
VI	3,3′-Dihydroxy-2,2′,4,4′,5,5′,6,6′-octachlorodiphenyl propane	Cl	OH	Cl	Cl	Cl	$CH_2CH_2CH_2$	0–25
VII	4,4′-Dihydroxy-3,3′,5,5′,6,6′-hexachlorodiphenyl methane	..	Cl	OH	Cl	Cl	CH_2	0–25
VIII	4,4′-Dihydroxy-3,3′,5,5′,6,6′-hexabromodiphenyl methane	..	Br	OH	Br	Br	CH_2	0–25
IX	4,4′-Dihydroxy-3,3′,5,5′-tetrabromodiphenyl methane	..	Br	OH	Br	..	CH_2	50–75

pounds more highly active than chlorination, as appears to be the case through the comparison of the activity of Compounds VII, VIII, II, and IX, is a fact that can be determined only through testing of compounds analogous to the highly active chlorinated compounds (IV and V).

Whether the X group to which the two phenyl groups are attached are of importance in their effect on the anthelmintic activity of these compounds cannot be determined from these data. However, it does appear that there is little difference between a methane and an ether linkage.

Spatial relationships between the atoms and groups on the molecule may be a factor in the anthelmintic activities of these compounds. However, the number of compounds tested are too few to permit an analysis and no conclusions can be drawn on the point.

SUMMARY

Seven compounds of the diphenyl methane series, one diphenyl propane and one diphenyl ether were tested for possible anthelmintic activity against *Raillietina*

cesticillus by means of the controlled test. Only two compounds, 2,2′-dihydroxy-3,3′,5,5′,6,6′-hexachlorodiphenyl methane and 2,2′-dihydroxy-3,3′,4,4′,5,5′,6,6′,-octachlorodiphenyl ether were found to possess a high degree of activity. The possible importance of the hydroxyl groups, both as to presence and position, the number and type of halogen atoms, and the type of linking between the two phenyl groups, is discussed. It is pointed out that the data are too few to permit valid conclusions on these points.

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PSEUDOSPELOTREMA AMMOSPIZAE SP. NOV., (TREMATODA: MICROPHALLIDAE) FROM THE SEASIDE SPARROW *AMMOSPIZA MARITIMA MACGILLIVRAII* (AUDUBON)

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During a recent study of seaside sparrows, *Ammospiza maritima macgillivraii* (Audubon), at the Duke University Marine Laboratory, Beaufort, North Carolina, four birds examined carried specimens of a new species of trematode belonging to the genus *Pseudospelotrema.* Of a total of 25 specimens recovered, 18 were from one host.

Pseudospelotrema ammospizae sp. nov.

Specific diagnosis: (all measurements are given in millimeters, and are based on stained specimens). With the characters of the genus. Body pyriform in shape, covered with spines which are coarse and heavy in the anterior region and small and inconspicuous at the extreme posterior end. Length varies from 0.47 to 0.84 (av. 0.64); width from 0.28 to 0.44 (av. 0.34), measured in region immediately anterior to testes. Subterminal oral sucker ranges from 0.07 to 0.09 (av. 0.08) in width and from 0.07 to 0.08 (av. 0.077) in length. Acetabulum measures 0.08 to 0.09 (av. 0.085) in diameter and is approximately equatorial in position. Prepharynx very short. Pharynx measures from 0.03 to 0.05 (av. 0.04) in length and from 0.03 to 0.05 (av. 0.04) in width. Esophagus moderately long, 0.04 to 0.05, bifurcating anterior to acetabulum. Crura short and wide, thick-walled irregularly lobulated, extending towards lateral body margins where they end near anterior level of acetabulum.

Cirrus pouch prominent, thick-walled, lies in transverse plane, dorsal to and, in some specimens, anterior to acetabulum. Seminal vesicle thin-walled, filling two-thirds to three-fourths the length of cirrus pouch. Ejaculatory duct, surrounded by relatively few, small prostate cells, occupying remaining length of pouch. Cirrus long, bearing short fine spines, distal end usually coiled within genital atrium: one extended cirrus measured 0.12. Testes ovoid, approximately equal in size, placed in lateral fields, on opposite sides of body; long axis ranges from 0.07 to 0.09 (av. 0.08).

Ovary irregularly oval in outline, measuring from 0.06 to 0.08 (av. 0.07) and lying slightly to right of acetabulum, anteriomedial edge being dorsal to sucker and ventral to cirrus pouch. Seminal receptacle well-developed, approximately one-half to two-thirds as large as ovary, located slightly posterior and medial to ovary. Vitellaria consisting of 6 to 8 large follicles on each side, extending in median and lateral fields from anterior region of ovary to posterior level of testes. A prominent, relatively short vitelline duct emerges from anterior region of follicles on each side and joins its fellow dorsally to ootype. Comon vitelline duct enlarges immediately into a small reservoir. Uterus occupies entire post-acetabular region, practically obliterating from view all structures posterior to the mid-level of ovary. The muscular metraterm is best observed in sections. Eggs numerous and thick-shelled, measuring from 0.008 to 0.011 in width by 0.015 to 0.02 in length (av. 0.01 by 0.018).

Common genital atrium located sinistro-lateral to acetabulum with which it sometimes may be contiguous.

Excretory pore lies in small indentation at extreme posterior tip of body.

Host: Ammospiza maritima macgillivraii (Audubon).

Location in host: Intestine.

Locality: Beaufort, North Carolina.

Type: Deposited in U. S. Nat. Mus. Helm. Coll. (No. 47829).

The genus *Pseudospelotrema* was established by Yamaguti (1939). Later in the same year Rankin erected the genus *Maritreminoides* which Baer (1943)

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reduced to synonomy with Yamaguti's genus. The following seven described species, therefore, belong to *Pseudospelotrema:*

P. japonicum Yamaguti, 1939.
P. uriae Yamaguti, 1939.
P. cincli Yamaguti, 1939.
P. nettae (Gower, 1938).
Syn.: *Maritrema nettae* Gower, 1938.
Maritreminoides nettae (Gower) Rankin, 1939.
P. obstipum (Van Cleave & Mueller, 1932).
Syn.: *Microphallus obstipus* Van Cleave & Mueller, 1932.
Maritrema obstipum (Van Cleave & Mueller, 1932) Mueller, 1934.
Maritreminoides obstipum (Van Cleave & Mueller, 1932) Rankin, 1939.
P. medium (Van Cleave & Mueller, 1932).
Syn.: *Microphallus medius* Van Cleave & Mueller, 1932.
Maritrema medium (Van Cleave & Mueller, 1932) Mueller, 1934.
Maritrema medium Sheldon, 1938.
Maritreminoides medium (Van Cleave & Mueller, 1932) Rankin, 1939.
P. ammospizae sp. nov.

Yamaguti erected the genus *Pseudospelotrema* for the inclusion of three species found in birds: *P. japonicum, P. uriae and P. cincli.* The first two species were placed in the subgenus *Pseudospelotrema.* The two species in this subgenus were separated from each other chiefly on the basis of the slightly larger egg size of *P. japonicum.* Since both forms were recovered from shore birds, and since they are so similar in morphological detail, it is possible that only one species is involved.

P. cincli was placed in the subgenus *Pseudospelotrematoides.* This subgenus was distinguished from the subgenus *Pseudospelotrema* by the prepharynx being "practically absent" and in having a convoluted seminal vesicle. When other species of *Pseudospelotrema* are considered, however, it becomes evident that this subgeneric distinction is not constant. There is great variation in length of the prepharynx in all of the species described. For instance, in *P. uriae* Yamaguti its length is said to vary from 24–105 micra; in *P. nettae* (Gower) it ranges from 0.01 to 0.03 mm. and in *P. cincli* Yamaguti it is so short as to be "practically absent." In *P. ammospizae* sp. nov. it is extremely short, and appears to be lacking in worms which are even slightly contracted. We consider the convolution of the seminal vesicle to be important only when separating species. In our opinion the separation of the genus *Pseudospelotrema* into subgenera is unwarranted. We also feel that Baer (1943) lacked valid arguments for questioning the placing of *P. cincli* in this genus. If the presence or absence of a cirrus pouch is important as a family characteristic, Baer, (1943) could not justifiably relate *P. cincli* to the genus *Pycnoporus* which is assigned to the family Troglotrematidae and lacks a cirrus pouch.

The question of the synonomy of *P. obstipum* and *P. medium* is still unsettled. If, however, the character of the vitellaria alone constitutes a valid reason for separation of species, and no intergrading conditions are found for the vitellaria, the two species should stand. Evidence at hand indicates that both species are correctly placed in the genus *Pseudospelotrema.*

Of the described species, *P. ammospizae* sp. nov. most closely resembles *P. cincli,*

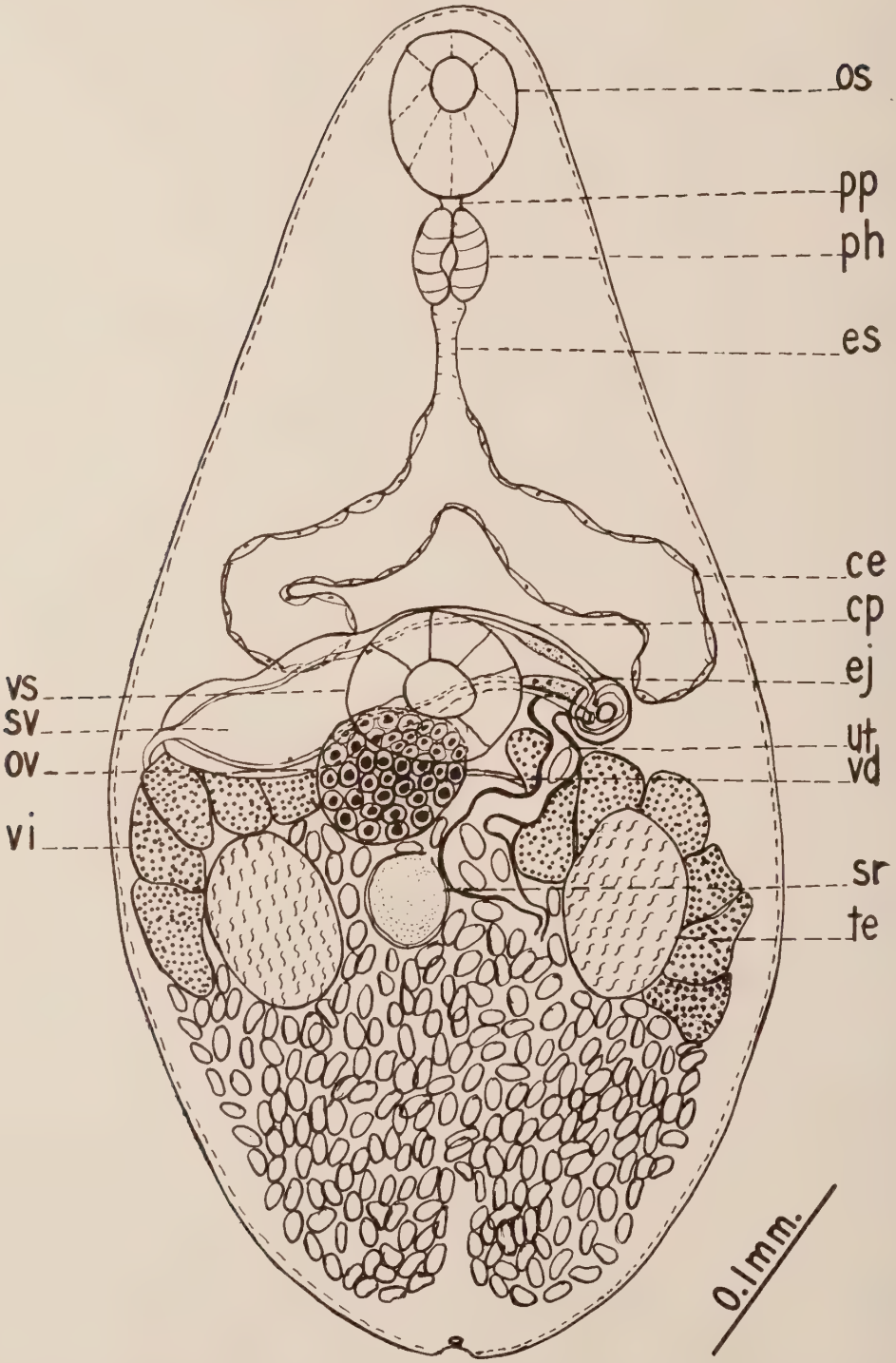

FIG. 1. *Pseudospelotrema ammospizae* sp. nov. enlarged from camera lucida drawing. *ce,* intestinal ceacum; *cp,* cirrus pouch; *ej,* ejaculatory duct; *es,* esophagus; *os,* oral sucker; *ov,* ovary; *ph,* pharynx; *pp,* prepharynx; *sr,* seminal receptacle; *sv,* seminal vesicle; *te,* testis; *ut,* uterus (metraterm); *vd,* vitelline duct; *vi,* vitellaria; *vs,* ventral sucker.

but may be distinguished from it by the thick-walled cirrus pouch, smaller esophagus, approximately equal sized suckers, the position and character of the vitellaria, and the lack of a convoluted seminal vesicle.

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MONOGENETIC TREMATODES OF WESTHAMPTON LAKE FISHES. III. PART 1. COMPARATIVE MORPHOLOGY OF THE SPECIES ENCOUNTERED*

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INTRODUCTION

The gill parasites of the order Monogenea (Platyhelminthes: Trematoda) discussed in the present paper were recovered from a series of 110 fishes of the families Centrarchidae, Cyprinidae, and Ameiuridae which were taken from Westhampton Lake, a 12 acre impoundment on the University of Richmond campus.

MATERIALS AND METHODS

A total of 4,711 flukes of 24 known and 2 undescribed species of the genera *Actinocleidus* Mueller, 1937, *Cleidodiscus* Mueller, 1934, *Dactylogyrus* Diesing, 1850, *Gyrodactylus* v. Nordmann, 1832, *Haplocleidus* Mueller, 1937, *Octomacrum* Mueller, 1934, and *Urocleidus* Mueller, 1934, were studied. These worms were recovered from the fish hosts during the summer, fall, and winter of 1950.

For a discussion of the methods and techniques employed the reader is referred to Hargis (1952a). The host material was identified using the keys and systematics of Kuhne (1939) and Hubbs and Lagler (1949). The flukes were studied, after fixation, in either glycerine jelly or permanent mounts. Measurements were made with an ocular micrometer. In the case of curved structures measurements are across the lines subtending the greatest arcs described by those structures (*i.e.* in the case of anchors, from the proximal tip of the longest root to the most distal point on the curve). In the descriptive material below, the number of worms or structures measured is given in parentheses, followed by (1) the average measurements and (2) the minima and maxima (enclosed in parentheses). All measurements are in millimeters.

All of the specimens in this collection are microscopic in size, or the organs of taxonomic importance are microscopic; therefore, each worm had to be carefully studied using the higher powers of the compound microscope. For this reason it is felt that any great deviation from the normal which might have occurred consistently would have been detected, particularly in important structures. Cotypes and paratypes were checked where necessary for the resolving of controversial points.

The hosts, by family, are: Ameiuridae—*Ameiurus nebulosus nebulosus* (LeSueur), Northern Brown Bullhead (11); Centrarchidae—*Chaenobryttus coronarius* (Bartram), Warmouth (18), *Lepomis gibbosus* (Linn.), Pumpkinseed Sunfish (7); *Lepomis macrochirus macrochirus* (Raf.), Bluegill Sunfish (34), *Huro salmoides* (Lacépède), Large-mouth Bass (6), and *Pomoxis nigromaculatus* (LeSueur), Black Crappie (10); Cyprinidae—*Notemigonus crysoleucas crysoleucas* (Mitchill), Eastern Golden Shiner (24); and Percidae—*Perca flavescens*

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(Mitchill), Yellow Perch (8). (The eight Yellow Perch were found to harbor no gill trematodes.) Since the common names of the hosts reported in this paper are given above they will not be repeated; however, these particulars for the fish hosts of other authors will be given once as they appear below. In those few cases where common names are used as host data the author must explain that they are all that is given in the original papers, and are employed herein as direct quotations.

The taxonomy employed in dealing with the parasites is essentially that of Price (1937) and Mizelle and Hughes (1938) with the exception that *Haplocleidus* Mueller, 1937, which was reduced to synonymy by Mizelle and Hughes (1938) and re-erected by Hargis (1952c), is herein accorded generic rank. No attempt is made to indicate phylogeny in the descriptions to follow.

Unless otherwise indicated the locality of the flukes represented in the present collection is Westhampton Lake or the creek below the dam, Richmond, Va.

RESULTS

Suborder Monopisthocotylea Odhner, 1912.
Genus *Gyrodactylus* v. Nordmann, 1832.
Gyrodactylus elegans v. Nordmann, 1832.
(Plate I, Figs. 1 to 5)

Host: *Lepomis m. macrochirus* (Raf.).

Previously reported hosts and localities: (For the U. S. only) *Carassius auratus* (Linn.), Goldfish and (*G. elegans* varieties A and B of Mueller, 1936) from New York, and "Cut-throat," "Brook," and "Brown" Trout from New York and Washington state.

Specimen studied: 1.

Body length 0.415 and width 0.092. Haptor 0.093 wide by 0.078 long, discoidal in shape with a concave ventral surface. Pharynx diameter 0.033. Anchor 0.070 long and 0.011 wide at the knob. Ventral bar 0.028 wide by 0.038 long. The hooks (Pl. I, Fig. 5) measure as follows:

Hook	*Right*	*Left*
1	0.032	obscured
2	0.033	0.038
3	0.032	0.035
4	0.032	0.040
5	0.032	0.040
6	0.035	0.038
7	0.034	0.035
8	0.038	0.035

The respective lengths of the embryos *in utero* are: first 0.190, and second 0.049.

Because this trematode has not been reported with any degree of certainty from this country, and since European material thus far has proven impossible to obtain, it is difficult to identify accurately. Mueller (1936a) stated, "Two forms of a worm similar to this species have been found on fish in this country, but for lack of the European *G. elegans* for comparison, it is impossible at present to decide definitely whether we are dealing with *G. elegans* itself or with parallel forms in our native fauna." Mueller reported these forms from the fins and body surface, not

from the gills where the present specimen was found. Very little light, thus, is thrown on a doubtful situation and the exact identity of the worm must remain *sub judice* until more facts are available.

Gyrodactylus species.
(Plate I, Figs. 6 to 10)

Host: *Ameiurus n. nebulosus* (LeSueur).

Specimens studied: 5.

Length (3) 0.371 (0.345–0.423), width (4) 0.071 (0.062–0.092). Anchor (3) 0.049 (0.039–0.058) long. Ventral bars (2) 0.015 (0.013–0.018) long. No dorsal bars were seen, but the ventral bars are generally rectangular in shape. The anchors appear to be partly hollow (Pl. I, Fig. 10) at the distal portion of the shaft and at the bend.

Due to the poor condition of these specimens accurate identification proved impossible. They can not be identified as *G. gurlyei* Price, 1937, *G. fairporti* Van Cleave, 1921, or *G. elegans* v. Nordmann, 1832.

Genus *Dactylogyrus* Diesing, 1850.

Members of the subfamily Dactylogyrinae may not be as rare in this hemisphere as originally thought, although they appear to be less common than are those of the subfamily Tetraonchinae.

Dactylogyrus aureus Seamster, 1948.
(Plate I, Figs. 11 to 19)

Hosts: *Notemigonus c. crysoleucas* (Mitchill), *Chaenobryttus coronarius* (Bartram), and *Lepomis m. macrochirus* (Raf.).

Previously reported host and locality: *Notemigonus crysoleucas auratus* (Raf.) Western Golden Shiner, in Oklahoma.

Specimens studied: 140.

The measurements of *D. aureus* closely approximate those given in Seamster's description. The vagina agrees in shape with that described by Seamster (1948), and is so characteristic that it is a strong diagnostic feature. The anchors, however, differ from those of the specimens studied by Seamster in that they have a peculiar, slight incurve distal to the main curve (Pl. I, Fig. 14) which occurred regularly on all of the specimens.

This worm possesses an unusual, compound accessory piece consisting of two elements. Seamster (1948) characterized the second part of the accessory piece as "a straight finger-like process arising from the basal part of the accessory piece." To clarify the terminology this process is herein designated the *second accessory piece* and the part described by Seamster as an accessory piece the *first accessory piece* (Pl. I, Figs. 16, 17, and 19).

Dactylogyrus parvicirrus Seamster, 1948.
(Plate I, Figs. 20 to 24)

Host: *Notemigonus c. crysoleucas* (Mitchill).

Previously reported host and locality: *Notemigonus crysoleucas auratus* (Raf.), Oklahoma.

Specimens studied: 15.

Length (3) 0.399 (0.250–0.524), width (3) 0.103 (0.077–0.140). Anchors (5) 0.044 (0.042–0.050) long. Average hook length 0.026. Pharynx diameter 0.013. Cirrus (3) 0.023 (0.018–0.028) long. Accessory piece (3) 0.014 (0.010–0.016) long. For a more detailed description see Seamster (1948).

Though only three worms were used there is a sizable discrepancy between these specimens and those of Seamster. The average length of his worms was "0.224 (0.180–0.270)," or 0.175 less than the length of the present specimens. The body width, cirrus, and accessory piece measurements are also greater than those given by Seamster. These differences are thought not to be due to differences in techniques of preparation.

Seamster did not mention a vagina for *D. parvicirrus,* although a close study of several of the specimens in the present collection reveals its presence, opening on the left body margin (Pl. I, Fig. 24).

Both species of *Dactylogyrus* should be studied further in an effort to clarify their affinities with each other and the other members of the genus.

Genus *Actinocleidus* Mueller, 1937.
Actinocleidus fergusoni Mizelle, 1938.
(Plate I, Figs. 25 to 30)

Hosts: *Lepomis m. macrochirus* (Raf.) and *Chaenobryttus coronarius* (Bartram).

Previously reported hosts and localities: *Lepomis m. macrochirus* (Raf.) from Wisconsin, Illinois, Tennessee, and Florida, and *L. humilis* (Girard), Orange-spotted sunfish, from Oklahoma.

Specimens studied: 547.

Measurements made during this study approximate those given in published accounts of the species and are not repeated.

Some of these worms naturally have melanistic (eye spot) granules scattered through the anterior portion of the body. The scattered condition of the granules is of common occurrence in other tetraonchids.

Pl. I, Fig. 29, shows the projection on the dorsal surface of the accessory piece which probably serves as the locus for the insertion of a contractor-levator muscle that acts as an aid in the process of copulation.

The pharynx of *A. fergusoni,* and of other worms, has been observed to be very muscular and elastic, and on many occasions has been seen almost completely protruded from the worm. In this position it is employed as an exploratory and grasping organ, and is capable of strong attachment to the substrate or to food material. The mouth and oral chamber are also very elastic. The protruded pharynx is shown in Pl. I, Fig. 26.

The present study indicates a possible synonymy between this fluke, *A. fergusoni* Mizelle, 1938, and *A. gracilis* Mueller, 1937, but more study is needed, particularly with Mueller's cotype material, before it can be established definitely.

Actinocleidus flagellatus Mizelle and Seamster, 1939.
(Plate I, Figs. 31 to 34)

Hosts: *Chaenobryttus coronarius* (Bartram) and *Lepomis m. macrochirus* (Raf.).

Previously reported host and locality: *Chaenobryttus coronarius* (Bartram) from Tennessee and Florida.

Specimens studied: 211.

Length (4) 0.295 (0.200–0.354), width (3) 0.040 (0.039–0.042). Peduncle (2) 0.037 (0.035–0.039) wide. Haptor (2) 0.062 (0.054–0.069) wide. Anterior anchor (4) 0.030 (0.029–0.031) long by (2) 0.013 (0.012–0.014) wide at base. Posterior anchor (4) 0.031 (0.030–0.035) long and (2) 0.011 wide at base. Anterior bar length 0.041 (0.039–0.042). Posterior bar (3) 0.024 wide by 0.022 long on the average. The posterior eye spots are larger than the anterior ones and are confluent in many specimens. Cirrus length (3) 0.043 (0.040–0.046). Accessory piece (3) 0.047 (0.042–0.050) long (Pl. I, Fig. 33, shows the accessory piece with a portion of its contractor-levator muscle attached).

A hitherto undescribed vagina was observed in this worm (Pl. I, Fig. 34). Mizelle and Seamster (1939) stated "vagina apparently wanting" and Mizelle and Cronin (1943) made no mention of it. The vaginal tube is narrow and somewhat irregular in shape, and opens to the exterior on the left body margin, terminating proximally in a characteristic seminal receptacle.

Actinocleidus fusiformis (Mueller, 1934) Mueller, 1937.

Synonyms: *Ancyrocephalus cruciatus* (Wedl, 1857) Lühe, 1909 as reported by Cooper (1915) (see Mueller, 1936a), and *Cleidodiscus fusiformis* Mueller, 1934.

Host: *Huro salmoides* (Lacépède).

Previously reported hosts and localities: *Huro salmoides* (Lacépède) from Florida, Oklahoma, Louisiana, and Tennessee; *Micropterus dolomieu* Lacépède, Small-Mouth Bass, from New York, Ohio, and Tennessee; and *Micropterus punctulatus* (Raf.), Kentucky Bass, from Tennessee.

Specimens studied: 54.

Length (5) 0.736 (0.580–0.988), width (5) 0.105 (0.070–0.154). Although the specimens in our collection are longer than those reported by Mizelle (1940) in his redescription of this form, the other body measurements do not differ sufficiently from those given by Mizelle to warrant their being recorded.

Actinocleidus oculatus (Mueller, 1934) Mueller, 1937.
(Plate II, Figs. 1 and 2)

Synonym: *Cleidodiscus oculatus* Mueller, 1934.

Host: *Lepomis gibbosus* (Linn.)

Previously reported hosts and localities: *Lepomis gibbosus* (Linn.), from Ontario, Canada, and New York, "Sunfish" from New York, and *L. macrochirus* (Raf.) from Louisiana.

Specimens studied: 95.

Length (4) 0.413 (0.285–0.520), width (2) 0.065 (0.054–0.085). Peduncle width 0.046. Haptor width 0.085. Anterior anchor 0.033 long by 0.013 at base. Posterior anchor 0.035 long by 0.012 wide at base. Anterior bars (3) 0.036 (0.033–0.042) long. The posterior bars averaged (3) 0.025 wide by 0.020 long. The posterior eye spots are larger than the anterior ones and are almost confluent with each other. Pharynx diameter 0.015. Cirrus length (3) 0.032 (0.030–0.037). Accessory piece length (3) 0.030 (0.026–0.035). There is a slight skirt-like ex-

pansion near the distal end of the cirrus (Pl. II, Fig. 2). The measurements of this fluke, particularly those of the critical hard parts, are practically the same as those given by other authors, although the worm is considerably longer.

Some of Mueller's (1934) cotype specimens of *A. oculatus* were available for study, and it is interesting to note that specimens of *A. sigmoideus* Mizelle and Donahue, 1944, and *A. gibbosus* Mizelle and Donahue, 1944, appeared on the same slides, as those containing *A. oculatus*. It is to be wondered if Doctor Mueller regarded them as natural variants of the latter, which they closely resemble, and hence did not describe them as new species at the time. Evidently the two species described by Mizelle and Donahue (1944) were collected from Cross Lake, New York, in 1934, ten years before they were reported.

Actinocleidus okeechobeensis Mizelle and Seamster, 1939.
(Plate II, Figs. 3, 4 and 18)

Host: *Chaenobryttus coronarius* (Bartram).

Previously reported host and locality: *Chaenobryttus coronarius* (Bartram) from Lake Okeechobee, Florida.

Specimens studied: 33.

Length (9) 1.233 (0.990–1.490), width (9) 0.171 (0.154–0.231). Anterior anchor length (6) 0.040 (0.038–0.048). Posterior anchor length (6) 0.031 (0.025–0.038). Anterior bar length (6) 0.034 (0.030–0.038). The posterior bars averaged (5) 0.022 wide by 0.025 long. Pharynx diameter (3) 0.063 (0.056–0.069). The posterior eye spots are larger than the anterior eye spots. Cirrus length (6) 0.038 (0.030–0.040). Accessory piece length (6) 0.034 (0.030–0.040). While the average length of the copulatory structures is smaller than that listed by Mizelle and Seamster (1939), the maxima are greater.

The consistent presence of clear, lens-like structures in close association with the melanistic granules of the eye spots was noted. The dark, pigmented granules that make up the eye spots are usually congregated into four definite masses in the head region of the worm. The fact that the lens-like structures are very close and ventral to the eye spots makes them difficult to see. The posterior ones are situated slightly anterior to their eye spots and the anterior ones are slightly posterior to their eye spots (Pl. II, Figs. 18 and 24). Dawes (1946) mentioned these lens-like structures, but not in the TETRAONCHINAE, and they have not been reported in the North American species of this subfamily. Their function can only be conjectured, but they probably play some role in photoreception because they are so closely associated with the eye spots.

This is the second report of this species.

Actinocleidus recurvatus Mizelle and Donahue, 1944.
(Plate II, Figs. 5 to 11)

Host: *Lepomis gibbosus* (Linn.).

Previously reported host and locality: *Lepomis gibbosus* (Linn.) from Ontario, Canada.

Specimens studied: 46.

Length (5) 0.381 (0.394–0.490), width 0.086. Anterior anchors (2) 0.036 (0.035–0.036) long. Posterior anchor (2) 0.039 (0.031–0.046) long. Anterior

bar (4) 0.039 (0.033–0.045) long. The posterior bars averaged (4) 0.028 wide by 0.018 long. Haptoral hooks run from 0.010 to 0.018 in length. Cirrus length (4) 0.022 (0.020–0.030). Accessory piece length (4) 0.018 (0.013–0.025). The vagina opens on the left side and is of very characteristic shape (Pl. II, Fig. 11). Many of these measurements are larger than those of the original description.

This is the second report of this fluke.

Actinocleidus sigmoideus Mizelle and Donahue, 1944.
(Plate II, Figs. 12 to 15)

Host: *Lepomis gibbosus* (Linn.).

New locality: Cross Lake, New York.

Previously reported host and locality: *Lepomis gibbosus* (Linn.) from Ontario, Canada.

Specimens studied: 34.

Length (3) 0.380 (0.324–0.460), width (3) 0.053 (0.046–0.062). Peduncle (3) 0.035 (0.034–0.047) wide. Haptor (3) 0.071 (0.066–0.077) in width. Anterior anchor (3) 0.033 (0.032–0.034) long. Posterior anchor length (3) 0.036 (0.035–0.036). Anterior bar length (3) 0.038 (0.037–0.039). Posterior bars averaged (3) 0.023 wide by 0.017 long. Pharynx diameter (3) 0.019 (0.018–0.019). The posterior eye spots are larger than the anterior ones and are somewhat confluent. Cirrus length (2) 0.022 (0.020–0.023). Accessory piece length (2) 0.015. Most of these measurements are greater than those given by Mizelle and Donahue (1944).

This is the second report of this worm. It is interesting to note that this New York locality is given on the basis of specimens found on Dr. J. F. Mueller's cotype slides of *A. oculatus* (Mueller, 1934) Mueller, 1937, as mentioned above.

Actinocleidus unguis Mizelle and Cronin, 1943.
(Plate II, Figs. 16, 17 and 19 to 22)

Host: *Huro salmoides* (Lacépède).

Previously reported host and localities: *Huro salmoides* (Lacépède) from Wisconsin and Tennessee.

Specimens studied: 7.

The measurements obtained in this study are similar to those of other studies and are not repeated. The accessory piece of this species is of unusual shape. Plate II, Fig. 16 shows that the articulation point of the basal portion of the accessory piece is actually hollow, forming a bursa or acetabulum in which the articulating knob of the cirrus rides. This hollow is herein designated the *accessory piece bursa.*

Genus *Cleidodiscus* Mueller, 1934.
Cleidodiscus capax Mizelle, 1936.
(Plate II, Fig. 23)

Host: *Pomoxis nigromaculatus* (LeSueur).

Previously reported hosts and localities: *Pomoxis nigromaculatus* (LeSueur) from Illinois, Maryland, New York, and Tennessee, and *P. annularis* (Raf.), Silver Crappie, from Illinois and Tennessee.

Specimens studied: 5.

The measurements obtained in this study are similar to those of other studies.

This is one of the largest of the tetraonchids, and is unique in that it often possesses a greatly enlarged pharynx that is disproportionate in size (Pl. II, Fig. 23).

Cleidodiscus pricei Mueller, 1936.

Host: *Ameiurus n. nebulosus* (LeSueur).

Previously reported hosts and localities: *Ameiurus nebulosus* (LeSueur) from Wisconsin, Ontario, Canada, New York, and Florida; *A. melas* (Raf.), Black Bullhead, from Oklahoma, Louisiana, Tennessee, and Ontario, Canada; *A. natalis* (LeSueur), Yellow Bullhead, from Florida and Tennessee; *Ictalurus lacustrus punctatus* (Walbaum), Channel Cat, from Florida and Tennessee; and *I. furcatus* (LeSueur), Fulton Cat, from Tennessee.

Specimens studied: 6.

Length (4) 0.415 (0.239–0.550). Greatest body width (6) 0.078 (0.046–0.123). Ventral anchor length (4) 0.048 (0.035–0.067). Dorsal anchor length (3) 0.038 (0.037–0.042). Ventral bar length (4) 0.040 (0.035–0.043). Dorsal bar length (2) 0.035 (0.033–0.038). Pharynx diameter (2) 0.019 (0.014–0.025). Cirrus length (6) 0.024 (0.020–0.025). Accessory piece length (5) 0.014 (0.010–0.018).

According to Mizelle and Regensberger (1945) *C. pricei* is a morphologically variable species, and this study supports their conclusion. There were almost as many minor variations in the accessory piece and haptoral bars as there were worms.

Cleidodiscus robustus Mueller, 1934.
(Plate II, Fig. 24)

Synonyms: *Cleidodiscus incisor* Mizelle, 1936, *Actinocleidus incisor* (Mizelle, 1936) Mueller, 1937, *C. incisor* (Mizelle, 1936) Summers, 1937, and *A. incisor* (Mizelle, 1936) Summers and Bennett, 1938.

Hosts: *Lepomis m. macrochirus* (Raf.) and *Chaenobryttus coronarius* (Bartram).

Previously reported hosts and localities: *Lepomis macrochirus* (Raf.) from Wisconsin, Ohio, Illinois, Tennessee, Florida, and Louisiana, *L. gibbosus* (Linn.) from Wisconsin and New York, "Sunfish" and "Bass" from New York, and *L. cyanellis* (Raf.), Green Sunfish, from Ohio and Illinois.

Specimens studied: 65.

The measurements obtained in this study are similar to those of other studies and are not given.

The clear, lens-like structures can be seen near the eye spots and are morphologically the same as those in *Actinocleidus okeechobeensis* above (Pl. II, Fig. 24).

C. robustus is one of the largest and most interesting of the tetraonchids, and its size and capacity for stain suggest its suitability for more intensive morphological study.

Cleidodiscus species.
(Plate II, Figs. 25 to 31)

Hosts: *Lepomis m. macrochirus* (Raf.) and *Chaenobryttus coronarius* (Bartram).

Specimens studied: 6.

Length (3) 0.433 (0.415–0.470), body width (3) 0.081 (0.077–0.085). Peduncle width 0.066. Haptor width 0.093. The haptor is discoidal in shape. Ventral anchor length (3) 0.021 (0.018–0.024). Dorsal anchor length (2) 0.020 (0.019–0.020). Ventral bar length (3) 0.018 (0.016–0.020). Dorsal bar length (3) 0.021 (0.019–0.023). The posterior eye spots are confluent in some worms. Pharynx diameter (2) 0.031 (0.025–0.037). Cirrus length (2) 0.055 (0.050–0.060). Accessory piece length (2) 0.043 (0.033–0.053).

The identity of these worms could not definitely be established. The taxonomic features are too similar to those of *Cleidodiscus robustus* Mueller, 1934, to regard it as a new species. Until more specimens can be secured and studied, it, therefore, will be left in this undecided state. Since one of the larger specimens of the species (not included in the measurements above) measured 0.645 long and 0.123 wide, it is suggested that the forms seen by us may be a developmental stage of *C. robustus*.

Cleidodiscus stentor Mueller, 1937.
(Plate II, Figs. 32 to 40)

Host: *Pomoxis nigromaculatus* (LeSueur).

Previously reported host and localities: *Ambloplites rupestris* (Raf.), Rock Bass, from Wisconsin and New York.

Specimens studied: 23.

Length (19) 0.529 (0.262–0.810), width (18) 0.093 (0.030–0.146). Haptor 0.092 wide by 0.073 long. Haptor oval in shape. Ventral anchor length (18) 0.036 (0.029–0.039), and width (11) 0.019 (0.015–0.025). Dorsal anchor (18) 0.031 (0.022–0.039) long by (11) 0.017 (0.015–0.022) wide at the base. Ventral bar length (13) 0.031 (0.018–0.044). Dorsal bar length (11) 0.028 (0.018–0.032). The hooks measured as follows: No. 1, (9) 0.015 (0.010–0.018), No. 2, (9) 0.018 (0.015–0.019), No. 3, (10) 0.019 (0.017–0.021), No. 4, (9) 0.020 (0.019–0.045), No. 5, (7) 0.015 (0.012–0.054), No. 6, (7) 0.018 (0.015–0.020), and No. 7, (6) 0.018 (0.012–0.020). The anterior eye spots are smaller than the posterior ones. Pharynx diameter (18) 0.047 (0.029–0.059). Cirrus (18) 0.047 (0.030–0.060) long. Accessory piece length (8) 0.045 (0.038–0.047). The vagina is of characteristic shape. Plate II, Fig. 40 shows the oviduct opening into the common genital pore. The measurements of our specimens are slightly larger in some respects than those of the original description.

The specimens from this locality are somewhat different from Mueller's (1937) original ones and those used by Mizelle and Regensberger (1945) in their redescription. Our specimens do not show the pronounced distal flaring of the cirrus that gives the worm its name, and the accessory piece is somewhat different. Superficially, then, the morphology of specimens would appear to be sufficiently distinct for the description of a new species, but after checking 30 specimens (Mueller's cotype slides) its identity was established as *C. stentor* Mueller, 1937. Although the cotypes, for the most part, showed pronounced distal flaring of the cirrus while most of our worms showed none, the demonstrated moderate to slight flaring of the cirrus (or its absence) suggests the presence of intergrades for this character between the two groups of flukes. This, coupled with the fact that the vaginae, anchors, bars, and hooks are virtually identical, lends validity to our identification.

Cleidodiscus vancleavei Mizelle, 1936.
(Plate III, Figs. 1 to 6)

Synonyms: *Onchocleidus formosus* Mueller, 1936, and *Cleidodiscus formosus* (Mueller, 1936) Price, 1937.

Host: *Pomoxis nigromaculatus* (LeSueur).

Previously reported hosts and localities: *Pomoxis nigromaculatus* (LeSueur) from Illinois and Oklahoma, and *P. annularis* (Raf.) from Illinois and Oklahoma.

Specimens studied: 195.

The measurements obtained in this study were similar to those of the original description.

The copulatory complex is characteristic for the species, but possesses a piece which was neither described nor figured by Mueller (1936b) or Mizelle (1938). This piece is an oddly shaped plate appearing to be of the same substance as the cirrus. It is so closely associated with the accessory piece that it must be a part of that structure and is herein considered as such (Pl. III, Fig. 4).

Genus *Haplocleidus* Mueller, 1937.

This genus was re-erected in a paper by Hargis (1952c), wherein a detailed discussion is given on its present status.

Haplocleidus dispar (Mueller 1936), Mueller, 1937.
(Plate III, Figs. 7 to 9, 11 and 23 to 25)

Synonyms: See Hargis (1952c).

Hosts: *Lepomis m. macrochirus* (Raf.), *L. gibbosus* (Linn.), and *Chaenobryttus coronarius* (Bartram).

Previously reported hosts and localities: *Lepomis m. macrochirus* (Raf.) from Wisconsin, Oklahoma, and Illinois, *L. gibbosus* (Linn.) from New York and Ontario, Canada, *L. humilis* (Girard) from Oklahoma, and *Huro salmoides* (Lacépède) from Tennessee.

Specimens studied: 368.

Measurements obtained during this study are like those of previous reports. Because the main dorsal anchor musculature was well defined in several stained specimens it is shown in Pl. III, Figs. 23, 24, and 25. The vagina is shown in Pl. III, Figs. 7 and 11, and is described here for the first time as a thin-walled, undulating tube which opens to the exterior on the right body margin of the worm. Although it is indistinct and difficult to see, it can be located in favorable specimens.

Haplocleidus furcatus Mueller, 1937.
(Plate III, Figs. 10 and 12 to 16)

Synonyms: See Hargis (1952c).

Host: *Huro salmoides* (Lacépède).

Previously reported hosts and localities: *Huro salmoides* (Lacépède) from Florida, Tennessee, Wisconsin, and Texas, and *Micropterus punctulatus* (Raf.) from Tennessee.

Specimens studied: 218.

The measurements obtained during this comparative study are similar to those of previous studies.

Genus *Urocleidus* Mueller, 1934.

Some aspects of the taxonomy of this genus were discussed by Hargis (1952c) in conjunction with the genus *Haplocleidus*.

Urocleidus chaenobryttus Mizelle and Seamster, 1939.
(Plate III, Figs. 17 to 22)

Hosts: *Chaenobryttus coronarius* (Bartram) and *Lepomis m. macrochirus* (Raf.).

Previously reported hosts and localities: *Chaenobryttus coronarius* (Bartram) from Tennessee and Florida, and *Lepomis miniatus* Jordan, Stumpknocker Sunfish, from Tennessee.

Specimens studied: 256.

Measurements obtained during this study are similar to those of other studies.

The bizarre structure winding around the cirrus in wide spirals is really a large vane and not a cirrus thread. It is connected throughout its length to the cirrus which, thus, has the appearance of a very wide bit or Archimedian screw (Pl. III, Figs. 19 and 21).

This fluke also possesses a vagina (Pl. III, Figs. 17 and 18). It is difficult to see, but can be detected in some stained specimens. It is thin-walled, very variable in shape, and appears most often like a loose sausage skin which is constricted spirally in several places.

Urocleidus doloresae Hargis, 1952.

Hargis (1952a) gave a detailed description and figures of this fluke.

Urocleidus ferox Mueller, 1934.

Synonyms: *Onchocleidus ferox* (Mueller, 1934) Mueller, 1936, *O. mucronatus* Mizelle, 1936, and *Urocleidus mucronatus* (Mizelle, 1936) Mizelle and Hughes, 1938.

Hosts: *Lepomis m. macrochirus* (Raf.), *L. gibbosus* (Linn.), and *Chaenobryttus coronarius* (Bartram).

Previously reported hosts and localities: *Lepomis m. macrochirus* (Raf.) from Wisconsin, Illinois, Oklahoma, Louisiana, Tennessee, and Florida, *L. gibbosus* (Linn.) from New York and Illinois, *L. humilis* (Girard) from Illinois and Oklahoma. It has also been reported as occurring on *L. m. macrochirus* and *L. humilis* hybrids, and *L. gibbosus* and *L. humilis* hybrids in some of these localities.

Specimens studied: 1,664.

Measurements obtained during this study did not differ appreciably from those obtained by other authors.

On the basis of the specimens studied herein and the confusion that existed between *Urocleidus mucronatus* and *U. ferox*, the contention of Mizelle and Donahue (1944) that they are identical is held as valid.

Urocleidus principalis (Mizelle, 1936) Mizelle and Hughes, 1938.
(Plate III, Fig. 26)

Synonyms: *Onchocleidus principalis* Mizelle, 1936 and *O. contortus* Mueller, 1937.

Host: *Huro salmoides* (Lacépède).

Previously reported hosts and localities: *Huro salmoides* (Lacépède) from Florida, Illinois, Tennessee, Wisconsin, and Texas, *Micropterus dolomieu* Lacépède, Small-mouth Bass, from Oklahoma, Illinois, and Tennessee, and *Micropterus punctulatus* (Raf.) from Illinois and Tennessee.

Specimens studied: 623.

Measurements obtained during this study agree closely with those of previous authors.

The egg of this species (Pl. III, Fig. 26) has an elogate, globose body (0.070 long) with terminal filaments at either end. One of these filaments is slightly longer than the other and has two small, bulbous, lateral projections which may aid in anchoring the egg to the mucous material of the gills. The other filament is shorter and possesses no projections. The egg wall is thin.

Urocleidus procax Mizelle and Donahue, 1944.
(Plate III, Figs. 30 to 36)

Host: *Lepomis gibbosus* (Linn.).

Previously reported host and locality: *Lepomis gibbosus* (Linn.) from Ontario, Canada.

Specimens studied: 68.

Length (3) 0.516 (0.477–0.550), width (3) 0.063 (0.058–0.061). Peduncle width 0.035. Haptor width 0.073. Ventral anchor (3) 0.054 long by 0.023 at base. Dorsal anchor length (3) 0.055 (0.053–0.056). Ventral bar length (3) 0.023 (0.020–0.025). Dorsal bar length (3) 0.027 (0.025–0.028). Cirrus length (3) 0.028 (0.025–0.030). Accessory piece length (3) 0.014 (0.010–0.023). These measurements differ appreciably (for some structures) from those given by Mizelle and Donahue (1944). Our specimens are noticeably larger than those from Canada.

The copulatory complex is characteristic for the species except the cirral thread is connected for some distance to the distal portion of the cirrus, and is, therefore, a cirrus vane (Pl. III, Figs. 31 and 34).

The vagina of this fluke (Pl. III, Figs. 30 and 33) is a thin-walled, straight tube with a curious projection protruding from its distal end. This projection is thought not to be an artifact, but its function is unknown.

This is the second report of this worm.

Suborder *Polyopisthocotylea* Odhner, 1912.
Genus *Octomacrum* Mueller, 1934.

Two described species of this genus are known (*Octomacrum lanceatum* Mueller, 1934, and *O. microconfibula* Hargis, 1952), although unidentified material was collected by Bangham (1940), Bangham (1944) and Bangham and Venard (1946). This, then, is the fifth report of a member of the genus.

Octomacrum microconfibula Hargis, 1952.
(Plate II, Figs. 27 to 29)

For a detailed description of this worm see Hargis (1952a).

Figures showing details of the hook in position on the haptor, an edge view of a partially closed haptoral clamp, and the clamp muscle are given on Plate III.

DISCUSSION AND SUMMARY

Twenty-six species of Monogenea, representing the genera *Actinocleidus* Mueller, 1937 (8), *Cleidodiscus* Mueller, 1934 (6), *Dactylogyrus* Diesing, 1850 (2), *Gyrodactylus* v. Nordmann, 1832 (2), *Haplocleidus* Mueller, 1937 (2), *Octomacrum* Mueller, 1934 (1), and *Urocleidus* Mueller, 1934 (5), were recovered from seven species of fish. All of the host specimens examined by the author were taken from Westhampton Lake and the creek below the dam, Richmond, Virginia.

A complete list of these flukes was presented by Hargis (1952b) as a new locality and region record. One of the species discussed, *Actinocleidus sigmoideus,* was discovered among the material contained on a slide of Mueller's (1934) cotypes of *A. oculatus,* taken from the gills of *Lepomis gibbosus* from Cross Lake, New York, by Mueller. *A. gibbosus* Mizelle and Donahue, 1944 (not in the present collection) was also found on these slides. New locality record.

In the comparative morphological study, certain hitherto unreported structures were observed and described. Some of the probable functions of these structures were suggested, and the terminology for some organs (*i.e.* accessory pieces of *Dactylogyrus aureus* and *Actinocleidus unguis*) has been slightly modified.

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PLATE I

Explanation Sheet

Gyrodactylus elegans v. Nordmann, 1832—Figs. 1 to 5.
1—Haptor
2—Anchor
3—Dorsal anchor
4—Ventral anchor
5—Haptoral hook

Gyrodactylus species—Figs. 6 to 10.
6—Haptor
7—Ventral bar
8—Anchor
9—Ventral bar
10—Anchor

Dactylogyrus aureus Seamster, 1948—Figs. 11 to 19.
11—Haptor
12—Haptoral hook
13—Bar
14—Anchor
15—Cirrus complex
16—Cirrus
17—*First accessory piece*
18—Accessory piece muscle
19—*Second accessory piece*

Dactylogyrus parvicirrus Seamster, 1948—Figs. 20 to 24.
20—Anchor
21—Bar
22—Accessory piece
23—Cirrus
24—Vagina

Actinocleidus fergusoni Mizelle, 1938—Figs. 25 to 30.
25—Vagina
26—Pharynx everted
27—Cirrus complex
28—Cirrus
29—Accessory piece
30—Accessory piece muscle

Actinocleidus flagellatus Mizelle and Seamster, 1939—Figs. 31 to 34.
31—Cirrus complex
32—Cirrus
33—Accessory piece with muscle
34—Vagina

Plate II

Explanation Sheet

Actinocleidus oculatus (Mueller, 1934) Mueller, 1937—Figs. 1 and 2.
1—Accessory piece
2—Cirrus

Actinocleidus okeechobeensis Mizelle and Seamster, 1939—Figs. 3, 4 and 18.
3—Cirrus
4—Accessory piece
18—Lens-like structures

Actinocleidus recurvatus Mizelle and Donahue, 1944—Figs. 5 to 11.
5—Accessory piece
6—Cirrus
7—Cirrus
8—Accessory piece
9—Cirrus
10—Accessory piece
11—Vagina

Actinocleidus sigmoideus Mizelle and Donahue, 1944—Figs. 12 to 15.
12—Accessory piece
13—Cirrus
14—Cirrus
15—Accessory piece

Actinocleidus unguis Mizelle and Cronin, 1943—Figs. 16, 17 and 19 to 22.
16—Accessory piece
17—Cirrus
19—Posterior anchor
20—Posterior bar
21—Anterior bar
22—Anterior anchor

Cleidodiscus capax Mizelle, 1936—Fig. 23.
23—Drawing of anterior end to show the striking relative size of the pharynx and the body width in that region.

Cleidodiscus robustus Mueller, 1934—Fig. 24.
24—Eye spots showing the lens-like structures between them.

Cleidodiscus species—Figs. 25 to 31.
25—Vaginal tube
26—Cirrus
27—Accessory piece
28—Ventral bar
29—Ventral anchor
30—Dorsal anchor
31—Dorsal bar

Cleidodiscus stentor Mueller, 1937—Figs. 32 to 40.
32—Cirrus
33—Accessory piece
34—Cirrus
35—Accessory piece
36—Anterior end of worm
37—Mouth
38—Pharynx
39—Cirrus
40—Genital pore

Plate III

Explanation Sheet

Cleidodiscus vancleavei Mizelle, 1936—Figs. 1 to 6.
1—Ventral anchor
2—Ventral bar
3—Vagina
4—"Hard" part of accessory piece
5—Accessory piece
6—Cirrus

Haplocleidus dispar (Mueller, 1936) Mueller, 1937—Figs. 7 to 9, 11 and 23 to 25.
7—Vagina
8—Accessory piece
9—Cirrus
11—Vagina
23—Dorsal anchor base
24—Dorsal bar
25—Dorsal anchor muscle

Haplocleidus furcatus Mueller, 1937—Figs. 10, 12 to 16.
10—Vagina
12—Haptor
13—Ventral anchor
14—Ventral bar
15—Dorsal anchor
16—Dorsal bar

Urocleidus chaenobryttus Mizelle and Seamster, 1939—Figs. 17 to 22.
17—Vagina
18—Vagina
19—Accessory piece
20—Cirrus
21—Cirrus
22—Accessory piece

Urocleidus principalis (Mizelle, 1936) Mizelle and Hughes, 1938—Fig. 26.
26—Egg of *U. principalis*

Octomacrum microconfibula Hargis, 1952—Figs. 27 to 29.
27—Anchor
28—Edge view of clamp
29—Part of retractor muscle which aids in clamp action

Urocleidus procax Mizelle and Donahue, 1944—Figs. 30 to 36.
30—Vagina
31—Cirrus
32—Accessory piece
33—Vagina
34—Cirrus
35—Accessory piece
36—Vagina

PLATE I

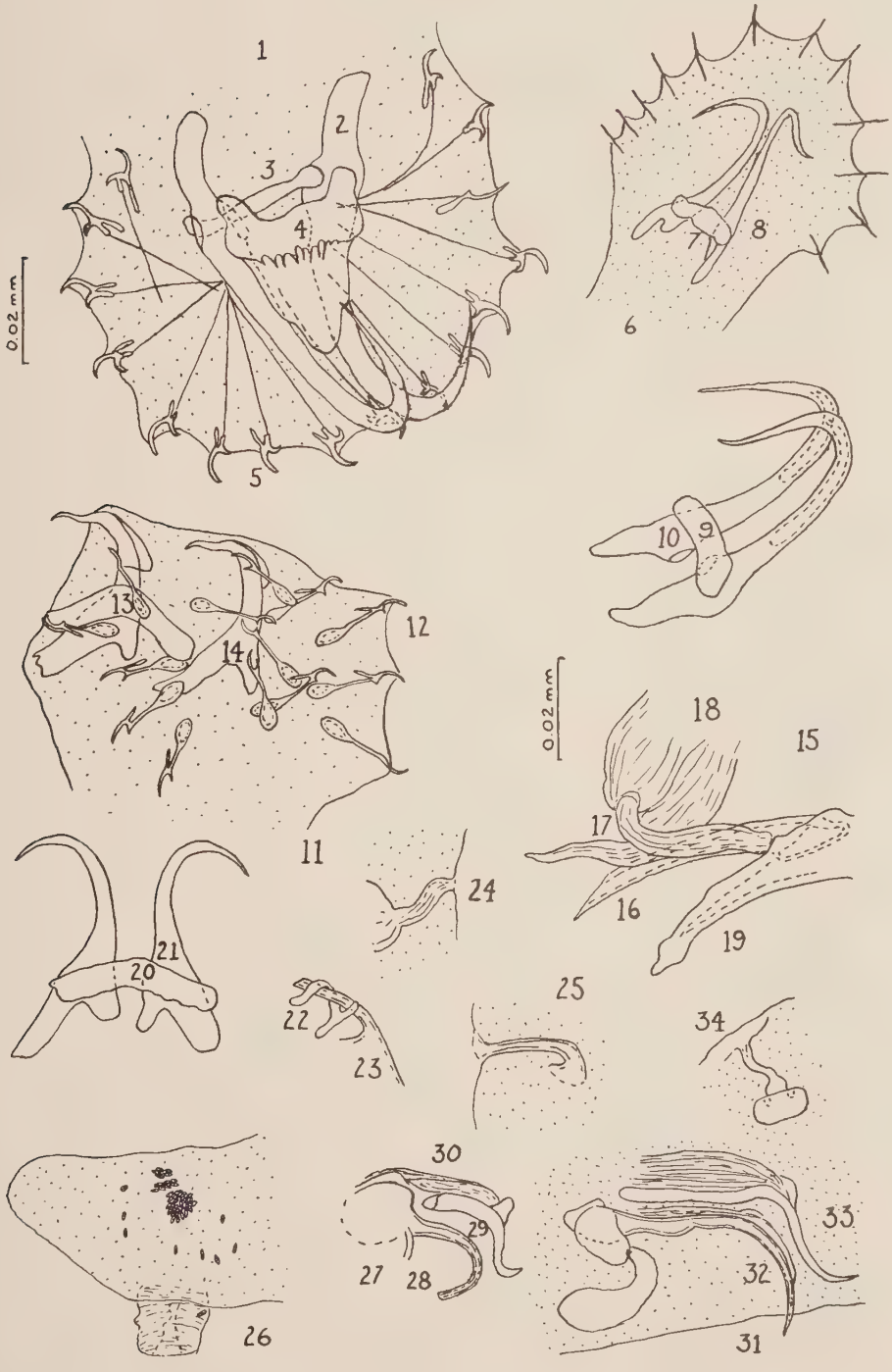
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PLATE II

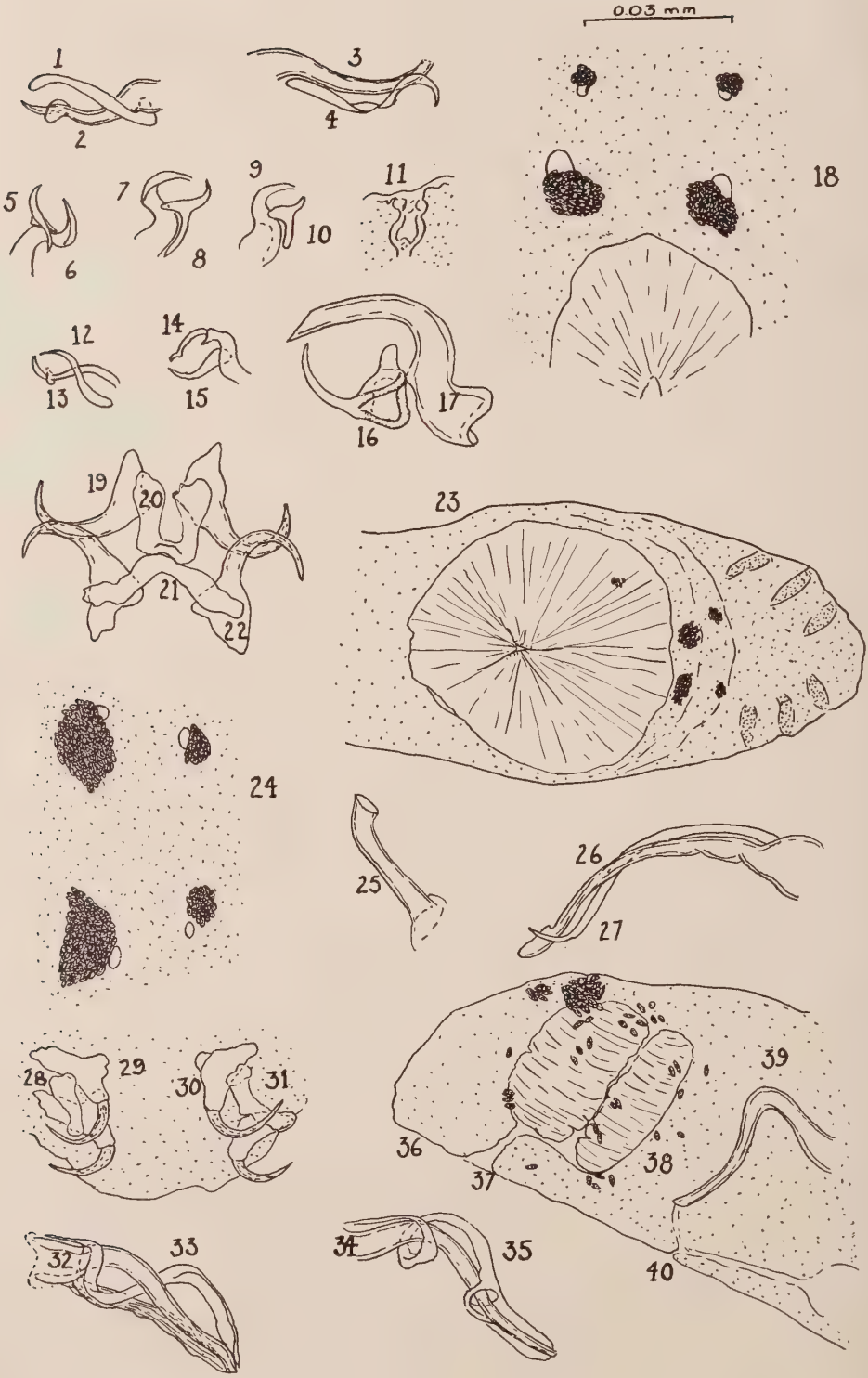
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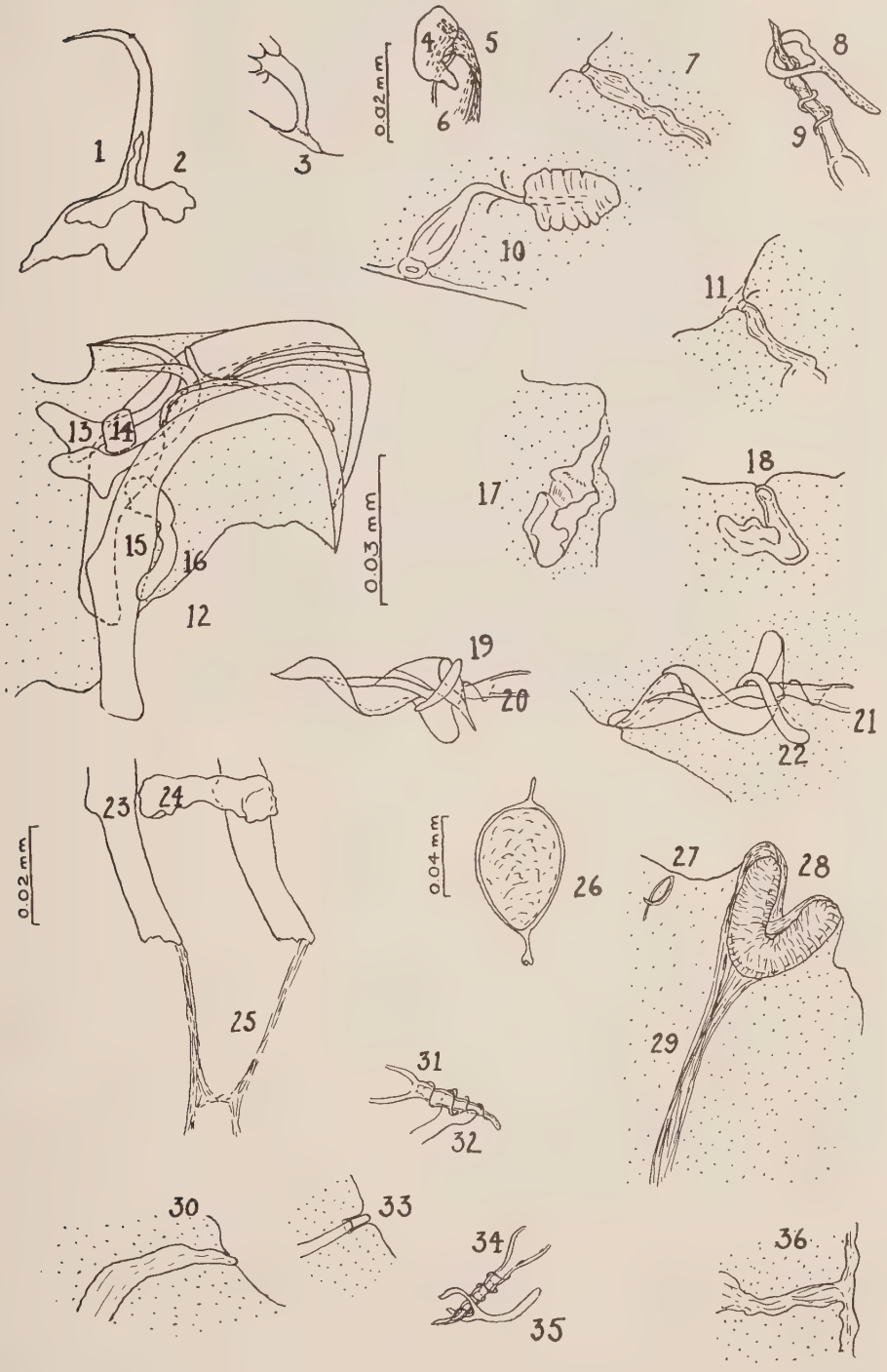
PLATE III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MAHMOUD ABDEL AZIM BEY M.B., Ch.B., CAIRO; D.T.M. AND H., LONDON

Robert E. Kuntz

Department of Helminthology, Naval Medical Research Unit No. 3, Cairo, Egypt

A. Gismann

Secretary, Bilharzia Snail Control, Ministry of Public Health

Mahmoud Abdel Azim born at Mansura, Dakahlia Province, Egypt, 22 February 1901, died of a heart attack in Cairo 15 January 1952 following recovery from influenza. By his premature death Egypt lost one of its most prominent figures in the fields of public health, parasitology and tropical medicine. He was at the height of his career serving as the Director General, Rural Health Department and Bilharzia Snail Control Section of the Egyptian Ministry of Public Health.

Dr. Abdel Azim graduated from the Faculty of Medicine at the Egyptian University in 1924. After serving a short term as clinical assistant at Kasr el Aini Hospital, and as a quarantine physician, he attended the London School of Tropical Medicine where he obtained his diploma in 1927. The following 14 years were spent as parasitologist at the Fouad El Awal Research Institute in Cairo. During this period his studies were concerned with helminthic diseases, special attention being given to various phases of the incidence, spread, treatment and prevention of schistosomiasis. Allied studies emphasized the importance of a knowledge of the biology of the snails serving as intermediate hosts for the schistosomes of man in Egypt. In addition to his research activities he was examiner in helminthology at the Faculty of Veterinary Medicine as well as a lecturer in the postgraduate courses of Tropical Medicine.

In 1941 he gave up his work at the Research Institute to join Dr. Claude H. Barlow who founded the Bilharzia Snail Control Section. Later under Dr. Abdel Azim's able directorship the Snail Control Section developed rapidly into one of the most active and widely known sections in the Ministry of Health. The section became the first organization whose sole function was to study and control the snail vectors of schistosomes.

His eminent qualifications as a scientist and his unusual personality were recognized throughout Africa and the Middle East and his advice was sought by various governments. He travelled widely having represented the Egyptian government at numerous scientific conferences in America and Europe. He contributed much to the formation of an Expert Study Group on Schistosomiasis in Africa which was sponsored jointly by the World Health Organization and the Office International d'Hygiene Publique. In 1950 he relinquished directorship of the Snail Control Section to become Director General of the Rural Health Department. This promotion did not deter his interests and obligations to studies relating to schistosomiasis in Egypt and the Middle East. At the request of WHO in 1950, and in the capacity of consultant he made a schistosomiasis field survey in several countries of the Middle East and Arabia. His work revealed the presence of the schistosomiases in regions where they had previously been unknown.

Although not in the best of health for many years Dr. Abdel Azim continued

دكتور محمود بك عبد العظيم
مدير عام مصلحة الصحة القروية وقسم مكافحة القواقع البلهارسية ١٩٥٠

Dr. Mahmoud Bey Abdel Azim
Director General Rural Health Department
and Bilhdrzia Snail Control Section
1950

his research activities and in spite of heavy administrative duties always found time to lecture at the Egyptian universities and help investigators in his field of specialization. It is assumed that his poor health was due in part to a boyhood infection of schistosomiasis, the disease he strived so earnestly to combat in his professional life. In later years an attack of tuberculosis left him with a single functional lung.

At the time of his death he was accredited with the publication of over forty papers in English, American, Arabic and continental journals. Although Dr. Abdel Azim's death cut short an outstanding and productive career, his services to Egypt and his contributions to the fields of parasitology and public health will be remembered by fellow scientists scattered over the world. Most of all he will be missed by his colleagues and followers who were inspired by his leadership and the wise handling of a multitude of obligations, both personal and professional, attendant to his position with the Egyptian government.

IN MEMORIAM

CHARLES ATWOOD KOFOID (1865–1947)

Since 1932 the Journal has been publishing the portraits of the presidents of the American Society of Parasitologists with their presidential addresses. Dr. Charles A. Kofoid was president of the Society in 1928 before this custom was started. Since the Journal has never published his portrait it is being presented in this issue. This time seems especially appropriate since this same issue contains the portrait and obituary notice of one of his best known students and successor as Department Chairman (Zoology) at the University of California, Dr. Harold Kirby.

Professor Kofoid was born in Granville, Illinois, on October 11, 1865. He received his undergraduate education at Oberlin College and his postgraduate training from Harvard University, obtaining the Ph.D. degree in 1900. He served at the University of Michigan from 1894 to 1895 and at the University of Illinois from 1895 to 1900. In 1900 he became a member of the Department of Zoology of the University of California; and from 1910 until his retirement in 1936, except for a period of four years, he was chairman of that department. He served as a Major in the Sanitary Corps during World War I. After retirement he lived in Berkeley, California, and continued actively in research and writing until his death on May 30, 1947.

Among the accounts of his life and work published after his death the most complete which includes a bibliography of his numerous publications was that by Richard B. Goldschmidt (Biographical Memoirs, National Academy of Sciences, Volume XXVI, 1949). A briefer obituary notice by Harold Kirby is found in Science (Volume 106, pp. 462 to 463, 1947).

CHARLES ATWOOD KOFOID

IN MEMORIAM

HAROLD KIRBY (1900–1952)

The death of Harold Kirby on February 24, 1952 marked the untimely end of a brilliant career devoted largely to the study of parasitic Protozoa. A native of Nova Scotia, Kirby received his undergraduate training at Emory University. His scholastic ability and promise were soon recognized by Professor R. C. Rhodes, who aroused Kirby's interest in the Protozoa and then sent him on to Berkeley for graduate training in the laboratory of Professor C. A. Kofoid. After receiving the Ph.D. degree in 1925, Kirby served as Instructor in Zoology at Yale University. He came back to join the Department of Zoology on the University of California's Berkeley campus in 1928, and he remained there for the rest of his life. In 1948, he became Chairman of the Department, a position he held at the time of his death.

Dr. Kirby's main interest was the flagellate fauna in the digestive systems of termites. He had first become fascinated by these remarkably complex protozoans during his graduate student days in Professor Kofoid's laboratory. He pursued this interest with a remarkable singleness of purpose during his entire scientific career. As a result of his accurate and careful work, we have today a clear picture of the history of highly specialized structures as they develop within a single termite flagellate, as well as a well documented explanation of the phylogeny of many members of the group. These studies reached their culmination in Kirby's (1946) address delivered before the American Society of Parasitologists in a symposium on "*Trichomonas* and related flagellates"—a symposium which he himself arranged as Vice-President of our Society. The concepts of the taxonomic and phylogenetic relationships of many of the termite flagellates were drawn largely from evidence which he himself had accumulated and in his address this evidence was masterfully and clearly presented. Dr. Kirby's studies on the termite flagellates alone would have made him one of the leading workers in protozoology, but his investigations covered a much wider field among the Protozoa, particularly the parasitic ones. Kirby's broad interests in the Protozoa were evident from the beginning of his scientific career and the extent of his knowledge is reflected in the two chapters which he wrote for "Protozoa in Biological Research." These two contributions, dealing with the relationships between Protozoa and other animals and with the parasites of Protozoa, contain a wealth of material presented with great clarity and they remain the authoritative treatments of these subjects.

Kirby's biological interests extended beyond the laboratory, for he was also a naturalist with a keen enjoyment of field work which he pursued in trips to the Fanning Islands, to Panama, as a Guggenheim Fellow to Africa, Madagascar and Java, and in his work at the Hastings Reservation of the University of California.

In all of his scientific investigations, Harold Kirby was an exceptionally careful and accurate worker. His conclusions were always based on ample evidence and his contributions to the science of protozoology were of fundamental importance. His care in observation and his enthusiasm for research were transmitted to his graduate students, who are carrying on in his tradition. His continuing interest in their welfare formed a bond that was rudely broken by his sudden death.

HAROLD KIRBY

Dr. Kirby joined the American Society of Parasitologists in 1928 shortly after its formation. His outstanding contributions and his good judgment were recognized by his election to the Editorial Board of the Journal of Parasitology in 1942–45, and by his choice again in 1951 for another three-year term. He served as Vice-President of the Society in 1946 and, as noted above, organized the very successful symposium presented at the annual meeting of that year.

Among the other honors which came to him were his election as a Fellow of the California Academy of Sciences in 1947, and as Vice-President of the Society of Protozoologists in 1952. He represented the American Society of Zoologists at the 13th International Congress of Zoology in Paris in 1948, serving also as an alternate member of the International Commission on Zoological Nomenclature. He served on the editorial board of the Journal of Morphology and as Chairman of the Board of Editors of the University of California Publications in Zoology.

Dr. Kirby leaves his wife, Margaret Thomson Kirby, also a student of Professor Kofoid's, and two children, Janet and Roger.

Although masked for the casual acquaintance by his quiet manner, the warmth and gentleness of Harold Kirby's personality endeared him to all who knew him well. His integrity, sound judgment, firm convictions, orderly habits, gentlemanly conduct, and friendly consideration of others, were outstanding traits which earned him the respect and liking of all his associates and students.

Gordon H. Ball and Richard P. Hall

AMERICAN SOCIETY OF PARASITOLOGISTS

Forty-second Council Meeting, Ithaca, New York, September 8, 1952

The meeting of the Council of the American Society of Parasitologists was called to order by President Emmett W. Price at 8:15 PM, September 8, 1952, in the Kimball Room, Willard Straight Hall, of Cornell University. Past Presidents James E. Ackert, William W. Cort, Thomas W. Cameron, Benjamin Schwartz, Norman R. Stoll, Horace W. Stunkard and the following members of the Council were present: Paul C. Beaver, Elon E. Byrd, George L. Graham, Paul D. Harwood, Chester A. Herrick, Gilbert F. Otto, Lloyd A. Spindler, Arthur C. Walton and George W. Wharton. Aurel O. Foster and Allen McIntosh also attended.

The regular order of business was taken up.

I. Reports of Officers and Members of Council

1. *Secretary (A. C. Walton):* As of September 8, 1952, there were 827 members of the Society, of whom 740 lived within the United States (27 are on temporary duty outside of the country) and 87 outside of the country. Of these, 106 were delinquent for one or more years' dues, 4 had resigned, and 2 had passed away, leaving a net membership in good standing of 642 domestic and 73 foreign, or a total of 715 active members. 34 of the 106 members who are delinquent for dues will be dropped at the end of 1952. 42 persons were elected during the time since the last meeting (Nov. 15, 1951–Sept. 8, 1952), all from this country. Later in the meeting the names of 16 additional persons will be presented to the Council for election to membership.

During the year notices of the deaths of Harold Kirby Jr. of the University of California, and of Peter H. McDermott of Jacksonville, Florida, were received. Notices of resignation were received from 4 people, including one charter member.

The office of the Secretary received $200.00 for incidental expenses during the fiscal year and attached receipts indicated expenditures to date of $115.92, with a cash balance of $84.08 remaining. Anticipated bills for the rest of the year, including expenses incurred by the Local Committee for this meeting will fall well within this margin. (N.B. Local Committee expenses totaled $35.50.) This financial statement was audited by the Auditing Committee appointed by the President and found to be correct.

The Secretary's report was accepted and ordered placed on file.

2. *Treasurer (R. M. Stabler):* In the absence of Dr. Stabler, Dr. Otto presented an interim statement of the status of the funds under the control of the Treasurer. For the period November 1, 1951, to September 1, 1952, the summary is as follows:

a. The balance on hand as of November 1, 1951, was $4,677.85
b. The collections from all sources to September 1, 1952, amounted to $11,046.47
c. Total funds for the period, therefore, were $15,724.32
d. Total expenditures for the period were $9,262.60.
e. Total cash balance as of September 1, 1952, is therefore, $6,461.72

The report as read was ordered placed on file. The Treasurer was requested to present a final report as of November 1, 1952: this report to be audited by the Auditing Committee (E. E. Byrd and C. A. Herrick) and when certified as correct, to be incorporated in the minutes of the Society as accepted. To implement this action the Council voted to rescind their action of March 26, 1946, setting the fiscal year as December 1 to December 1, and substituting the dates November 1 to November 1.

3. *Custodian of the Endowment Fund (N. R. Stoll):* The Custodian's report to the Council for the period November 15, 1951, to August 31, 1952, is as follows:

Fourth (Twenty-third) Year

		Period ending August 31, 1952	Period ending November 15, 1951
A.	Savings account to begin period	$368.46	$359.42
	Interest earned, current period	9.27	9.04
	Other additions, current period	none	none
	Savings account, end of period	377.73	368.46
B.	U.S. Savings Bond of Jan. 1950		
	Redemption value $2\frac{1}{2}$–3 years	754.00	745.00
	The Endowment Fund, end of period	$1131.73	$1113.46

A. Savings account No. 5197 of the Princeton Savings and Loan Association, Princeton, N. J., in the name of the "American Society of Parasitologists, Dr. Norman R. Stoll, Custodian," in exhibit showing interest entries and current balance.

B. $1,000.00 United States Savings Bond, Series F, No. M1 681 662 F, in the name of "American Society of Parasitologists, A Corporation (Endowment Fund)," in exhibit showing purchase price of $740.00, issue date, Jan., 1950, and a table of redemption values.

The Custodian bespeaks the interest of those who believe in parasitology (including parasitologists themselves) in remembering and befriending the Endowment Fund.

Ex-officio co-trustees for 1952: E. W. Price, President; R. M. Stabler, Treasurer.

The report was audited by E. E. Byrd and C. A. Herrick; found to be correct; and was accepted by the Council and ordered placed on file.

4. *Chairman of the Editorial Committee (H. W. Stunkard):* The report of the Editorial Committee concerned only the December number of Volume 37 (1951) and the first four numbers and supplement of Volume 38 (1952). Although printing costs are high, the cost per page of the current volume compares favorably with the costs of Volume 37. A change in the method of binding from stitching to stapling has accomplished slight but worthwhile savings.

The Chairman reported that since November 15, 1951, 129 manuscripts have been received; 23 of them Research Notes. Since that date, 71 papers have been published; 27 are in corrected galley; 13 in galley are in the hands of authors for correction; one is at the Press to be put in galley; and 15 papers have been returned to authors for revision. Manuscripts received in form for the printer have been published in about six months, often in less time.

On behalf of the Editorial Committee, the Chairman wishes to express to the members of the Editorial Board, to other specialists who have served as editorial consultants, to the many authors, and to the Press—especially the manager, Mr. George M. Houck—the appreciation of the Editorial Office for their hearty co-operation.

The report was accepted and ordered placed on file, with an expression of appreciation for the work of the Editor and his Committee.

5. *Custodian of Back Issues (G. F. Otto):* The financial business of the Custodian's office for the period November 1, 1951, to August 31, 1952, was summarized. Sales in the ten month period have increased over 40% over the previous high of 1951, with a rate approximating $3,000.00 for the complete 12 month period. 18 back issues have been duplicated during the past year and the duplication of at least 10 more issues is planned for the coming year. Duplication costs of $2,000.00 per year and sales of $3,000.00 will permit the meeting of the first installment of the original loan, due in 1954, without difficulty. The sale of the 25 volume index is rapidly amortizing the original cost and should show a profit within two years. The detailed financial statement shows a current balance of $705.89.

The financial statement was examined by E. E. Byrd and C. A. Herrick and found to be correct. The report was accepted by the Council and ordered placed on file.

II. Reports of Standing Committees

1. *Committee on Visual Instruction (M. S. Ferguson, Chr.):* The committee has prepared a list of film catalogs, lists, and reviews of value to those seeking information on protozoa, helminths, arthropods, etc., which appeared in the Program Supplement of the Journal (Aug., 1952). Further information is in preparation. The Council accepted the report and continued the committee with authorization to present short notes from time to time which will appear in the Journal.

2. *Committee on Terminology of Avian Strains of Malaria (C. G. Huff, Chr.):* The report indicated that work is continuing on the designation of avian strains and that when a sufficient number have been so designated, the list will be submitted for possible publication in the Journal. The Council accepted the report and authorized the continuation of the committee as now constituted.

3. *Committee on Common Names of Helminths (P. D. Harwood, Chr.):* The committee submitted a list of common names for the parasitic helminths of animals and has nearly completed a similar list for helminths parasitic in plants. The Council accepted the report and continued the committee, authorizing the printing of such lists as soon as possible in the Journal. They recommended that where deemed advisable, the list contain the generic names in the form of common nouns as suggested terminology, or at least as alternative common names. J. R. Christie has been the source of most of the information concerning the plant parasitic forms. Free-living forms are not to be included for the present.

4. *Auditing Committee (E. E. Byrd and C. A. Herrick):* The committee audited all financial reports submitted and the results of their examinations are recorded under such reports.

III. Reports of Representatives

1. *To Council of A.A.A.S. (A. O. Foster and K. C. Kates):* A schedule of future meetings of the A.A.A.S. was submitted as follows: 1952, St. Louis; 1953, Boston; 1954, San Francisco; 1955, Chicago; and 1956, New York. Other matters of business of the A.A.A.S. Council were mentioned, but contained nothing of particular importance to this Society. The report was accepted and ordered placed on file.

2. *To Governing Board of the American Institute of Biological Sciences (W. W. Cort):* Dr. Cort reported on the continuing activities of the A.I.B.S., calling attention to the increasing coordination within the field of the Biological Sciences through the work of the Institute, and issuing an invitation for the Society to continue meeting with the A.I.B.S. members. The meeting for 1953 is to be held on the campus of the University of Wisconsin at Madison from September 7 to 10. The report was accepted and placed on file.

3. *To the Division of Biology and Agriculture, National Research Council (A. C. Walton):* The annual all-day Division meeting, held May 8, 1952, at the NAS-NRC Building, Washington, D. C., was well attended; nearly all member Societies being represented. Most of the time was devoted to reports of the various activities sponsored by the Division, especially those concerning the Pacific area. A proposal to set up a number of sub-committees to serve as informational sources in various aspects of Biology was discussed. The Division also expressed a desire to gain closer cooperation between itself and the member Societies by having a hand in the selection of Society representatives and thus to build up a group of selected workers in the various fields. A five-year term was suggested as the minimum length of service of such representatives. The Council accepted the report and ordered it placed on file, reiterating its intention of maintaining control of the selection of the Society representative entirely within the hands of the Society, and again naming the Secretary of the Society as automatically being that individual.

IV. Old Business

1. *Report of Special Committee on Nomenclature (G. W. Wharton, A. McIntosh, D. H. Wenrich):* The committee incorporated the results of its studies in the form of two letters: one to the Comité International Permanent des Congrès de Zoologie and the other to the Secretary of the International Commission on Zoological Nomenclature, with the recommendation that the letters be forwarded to the addressees and that their contents be accepted as coming from the American Society of Parasitologists. The report was accepted and ordered placed on file together with copies of the letters. Dr. Wharton was authorized to prepare suitable copies of each letter for such forwarding.

V. New Business

1. *Election to Active Membership:* Sixteen applicants were elected by the Council to active membership in the Society:

Anderson, Everett, 3209 Sampson St., Houston, Texas
Bair, Thomas D., Dept. Biology, Utica College of Syracuse Univ., Utica, N. Y.
Barron, Charlie N., Armed Forces Institute of Pathology, Washington 25, D. C.
Batte, Edward G., 407 Hopkins Fd., Haddonfield, N. J.
Berstein, Emil, 305 Marshall St., Syracuse, N. Y.
Berry, Jewel, 1103 E. 22nd St., Kansas City, Mo.
Crossley, Deryee A., Jr., Dept. Entomology, Univ. of Kansas, Lawrence, Kans.
Hiromatsu, Seiichiro, Nishihama, Division 13, Aki-Machi, Aki-Gum, Kochi, Shikoku, Japan.
Holt, Carvel J., Lab. Trop. Diseases, USPHS, Federal Correctional Institution, Seagoville, Texas
Jaroslow, Bernard N., Dept. of Bacteriology, Univ. of Chicago, 5724 S. Ellis Ave., Chicago 37, Ill.
Kean, B. H. (MD), 710 Park Ave., New York 21, N. Y.
McEnerney, Philip J., James Law Hall, New York State Vet. Coll., Ithaca, N. Y.
Powers, Daniel, 25 West 64th St., New York, N. Y.
Schwab, William, Armour & Co., Research Div., Union Stock Yards, Chicago 9, Ill.
Singer, Ira, 5724 S. Ellis Ave., Chicago 37, Ill.
Yeager, Robert G., Dept. of Bacteriology & Parasitology, Univ. of Texas, Medical Branch, Galveston, Texas

2. *Election to Foreign Honorary Membership:* The Council unanimously voted to elect the following four outstanding Foreign Scientists to Honorary Membership (no more than twelve may hold such membership at any given time): Maj. Gen. Sir Gordon Covell of England, Dr. Jean G. Baer of Switzerland, Prof. Jerome A. H. Rodhain of Belgium, and Dr. Hans Vogel of West Germany.

3. *Election to Life Membership:* The Council unanimously voted to recommend to the Society the election of Dr. A. S. Pearse as a life member of the American Society of Parasitologists in recognition of his long and outstanding service in the field of Parasitology.

4. *Annual Meeting:* After consideration of the invitations of the A.A.A.S. and of the A.I.B.S., to meet with those groups in 1953, the Council authorized the Secretary to present the matter to the entire membership at the time of the Presidential Address and to state that a vote on the matter would be called for at the annual business meeting—a majority vote at that time to determine the place (and time) of the 1953 meeting. (N.B.: the A.A.A.S. meets at Christmas time as follows:—1953, Boston; 1954, San Francisco; 1955, Chicago; 1956, New York; and the AIBS meets in early September as follows:—1953, Univ. of Wisconsin; 1954, Univ. of Florida; 1955, Michigan State; 1956, Univ. of Connecticut; 1957, Leland Stanford Univ.)

5. *Fiscal Year:* The Council voted to rescind the action of March 26, 1946, setting the fiscal year as December 1 to December 1, and substituting the dates of November 1 to November 1, effective immediately. Those handling funds are to submit final financial reports—subject to audit—to be included in the minutes by consent whenever such minutes of the annual meeting should be based on interim reports due to meetings held before the November 1 date.

6. *Invitation to accept membership in the Agricultural Research Institute:* The Council voted to recommend to the Society at the annual business meeting that the Society accept a Class B (non-dues-paying) membership in the Agricultural Institute of the National Research Council. Each such Society Member (Class B) is entitled to a representative and an alternate with power to vote at the annual meeting of the group. 10 of the 27 members of the Governing Board of the Institute shall be elected by Class A (contributing) members from among the Class B representatives and the other 17 from among the Class A representatives. Expenses of such selected representatives (27) shall be paid from funds available to the Institute. Expenses of representatives not elected to the Governing Board must be borne by the organizations they represent.

7. The Council discussed a resolution presented by the Ecological Society of America requesting the proper Governmental agencies involved to continue their program of measuring the ultra-violet radiation. No Council action authorized.

8. The Council discussed a request from the National Society for Medical Research for financial support in combatting the anti-vivisection movement. The Council voted their continued support of the movement but were not in a position to vote any financial aid.

9. A request presented by Dr. Harold Elishowitz, Chicago Medical College, that the Society sponsor the compilation of a catalog of Parasitic Cultures maintained in the U.S.A. was discussed. In view of the seeming duplication of efforts put forth by other groups pertaining to the same general end, no action was taken, but the matter is to continue under study awaiting the outcome of these other activities.

10. Invitations to accredit delegates to several International Biological Congresses were discussed and the following actions taken:

a. First Inter-American Congress of Public Health, Sept. 26–Oct. 1, 1952, Havana, Cuba. D. B. McMullen and W. H. Wright were designated as delegates.
b. Fourth International Congress of Hydatosis, Nov. 21–24, 1952, Santiago, Chile. W. H. Wright designated as delegate.
c. Fourteenth International Congress of Zoologist, Aug. 5–12, 1953, Copenhagen, Denmark. J. E. Ackert, N. R. Stoll and D. H. Wenrich designated as delegates.
d. Fifth International Congress of Tropical Medicine and Malaria, Aug. 28-Sept. 4, 1953, Istanbul, Turkey. J. E. Ackert, G. F. Otto, C. B. Philip and N. R. Stoll designated as delegates.
f. Sixth International Congress for Microbiology, Sept. 6–12, 1953, Rome, Italy. J. E. Ackert, G. F. Otto, C. B. Philip, N. R. Stoll and D. H. Wenrich designated as delegates.

The Council regrets that Society funds are not available to aid such designated delegates from a financial standpoint.

11. *Nominations, Elections and Appointments to Society Offices:*

a. *Nominations:* On the basis of 111 ballots returned in response to the Secretary's call, the following persons (in each case those who received the greatest number of votes) were nominated by the Council for the designated offices in the Society for 1953: *President,* C. B. Philip; *President-Elect* (if the Society votes to accept the amendment adding this position to the list of elected offices), E. R. Becker; *Vice-President,* H. W. Brown; *Treasurer* (2 yr. term), R. M. Stabler; *Council Members at Large,* A. McIntosh and D. V. Moore (terms run through 1956).
b. *New Editorial Board members appointed:* The Council appointed E. E. Byrd, G. R.

Coatney, W. L. Jellison to 4 yr. terms, and W. Balamuth to a 2 yr. term to fill a vacancy.

c. *Committee to obtain nominees for the position of Editor and nominees for membership on the Editorial Committee of the Journal of Parasitology:* The terms of the present holders of these positions expire at the end of 1953 and elections must be made at the next Meeting of the Council. The President appointed W. W. Cort, Chr., N. R. Stoll and H. W. Stunkard to this committee.

The Council voted to adjourn at 12 midnight.

Respectfully submitted,
A. C. Walton, Secretary

AMERICAN SOCIETY OF PARASITOLOGISTS
TWENTY–SEVENTH ANNUAL GENERAL BUSINESS MEETING
SEPTEMBER 10, 1952

The general business meeting of the Society was called to order by the Society President, E. W. Price, at 1:30 PM following the annual luncheon in the Auditorium of Statler Hall, Cornell Campus, Ithaca, N. Y. One hundred and sixty-nine persons were present.

1. Reports of Officers, Custodians, Committees and Society Representatives were read and approved.

2. The proposed amendment to *Article III, Officers* of the Constitution of the Society, having been presented to the membership at the 1951 annual meeting, was called up for vote and was unanimously passed by the Society. The Article now reads "The officers of the society shall be a President, *President-Elect,* Vice-President," etc., and "The Council shall consist of the President, *President-Elect,* Vice-President," etc.

3. In accord with the Constitution, the Council unanimously recommended that the Society elect Dr. A. S. Pearse to Life Membership in the Society in recognition of his outstanding service to the Society as a charter member of the organization as well as in recognition of his over-all contributions to the general field of Parasitology. Election was by unanimous ballot.

4. The names of sixteen individuals elected to active membership at the Forty-Second Council Meeting were read. The names of the four elected to foreign honorary membership were also announced.

5. The Council presented the recommendation concerning accepting membership in the Agricultural Institute of the National Research Council as a Class B (non-dues-paying) participant. The Society voted to accept and the President appointed Benjamin Schwartz to represent the Society at the organization meeting of the Institute to be held in Washington early in October.

6. The President announced the appointment of a Special Committee to search for potential successors to the Editorship and to membership on the Editorial Committee of the Journal of Parasitology. These offices extend through a term of 5 years, and the current term expires December 31, 1953.

7. The names of those designated to act as Society Representatives at various International Congresses were announced, as well as the Council action in response to various requests presented to them during the year.

8. The officers and Council Members of the A.S.P. as nominated at the Forty-Second Council Meeting, were elected to their respective offices. Announcment was made of the Council appointees to membership on the various Standing Committees of the Society.

9. The matter of a meeting place for 1953 was presented and the Society voted by a large majority to meet with the A.I.B.S. at Madison, Wisconsin, September 7–10, 1953.

10. Votes of appreciation to various organizations and individuals concerned with the very successful twenty-seventh annual meeting of the Society were passed and the Secretary was instructed to convey such appreciation to the proper parties.

The Society voted to adjourn at 2:30 PM.

Respectfully submitted,
A. C. Walton, Secretary

Dates for mailing of numbers of volume 38 (1952):

No. 1, February 5.
No. 2, April 11.
No. 3, June 11.
No. 4, August 18.
No. 5, October 21.
No. 6, December 26.

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